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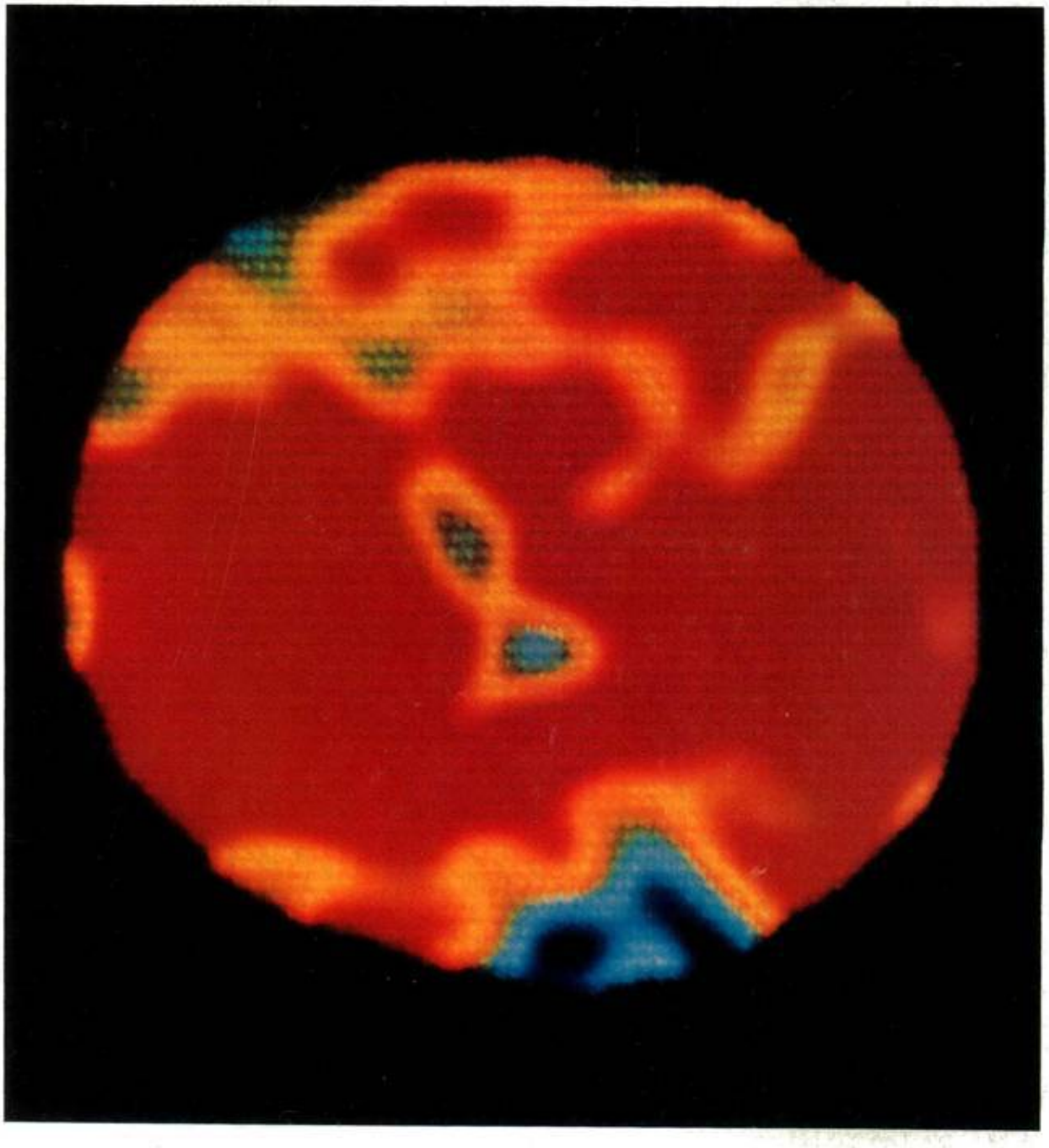

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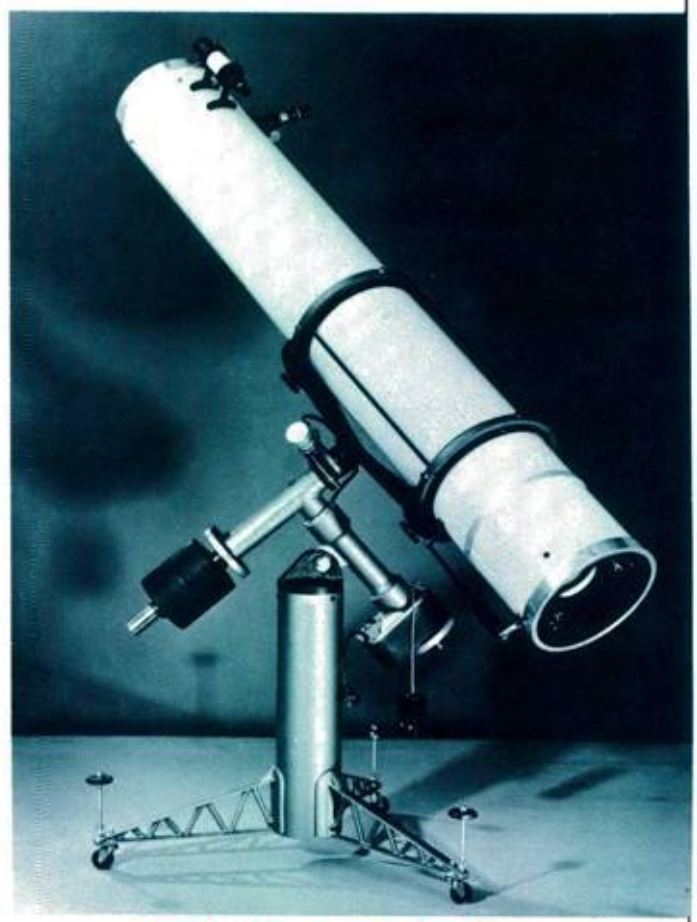

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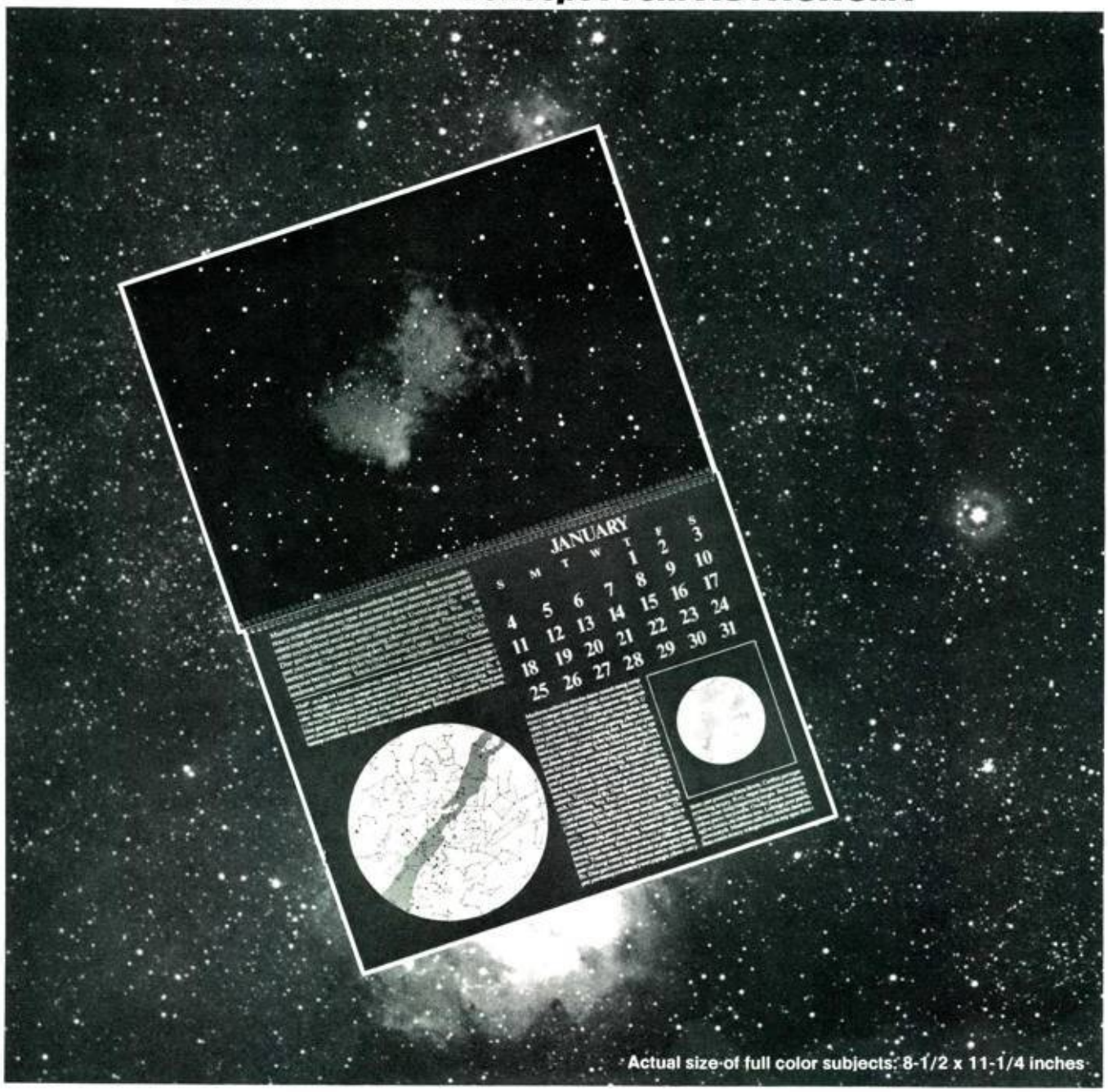

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October 1975 Vol. 3, No. 10

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COVER

"Starspots" best describes the features seen in this actual image of Alpha Orionis, commonly known as Betelgeuse. The vivid colors were supplied by the IPPS (Interactive Picture Processing System) — a new imaging system at Kitt Peak National Observatory. The starspots on the surface of the red giant star are similar to sunspots found on the sun. The photograph of the star's disk — 500 light-years away — was recorded in short exposures; an image intensifier was used to amplify the brightness. Computer processing eliminated any remaining blur, allowing investigators to recover actual images of the star. Kitt Peak National Observatory photograph.

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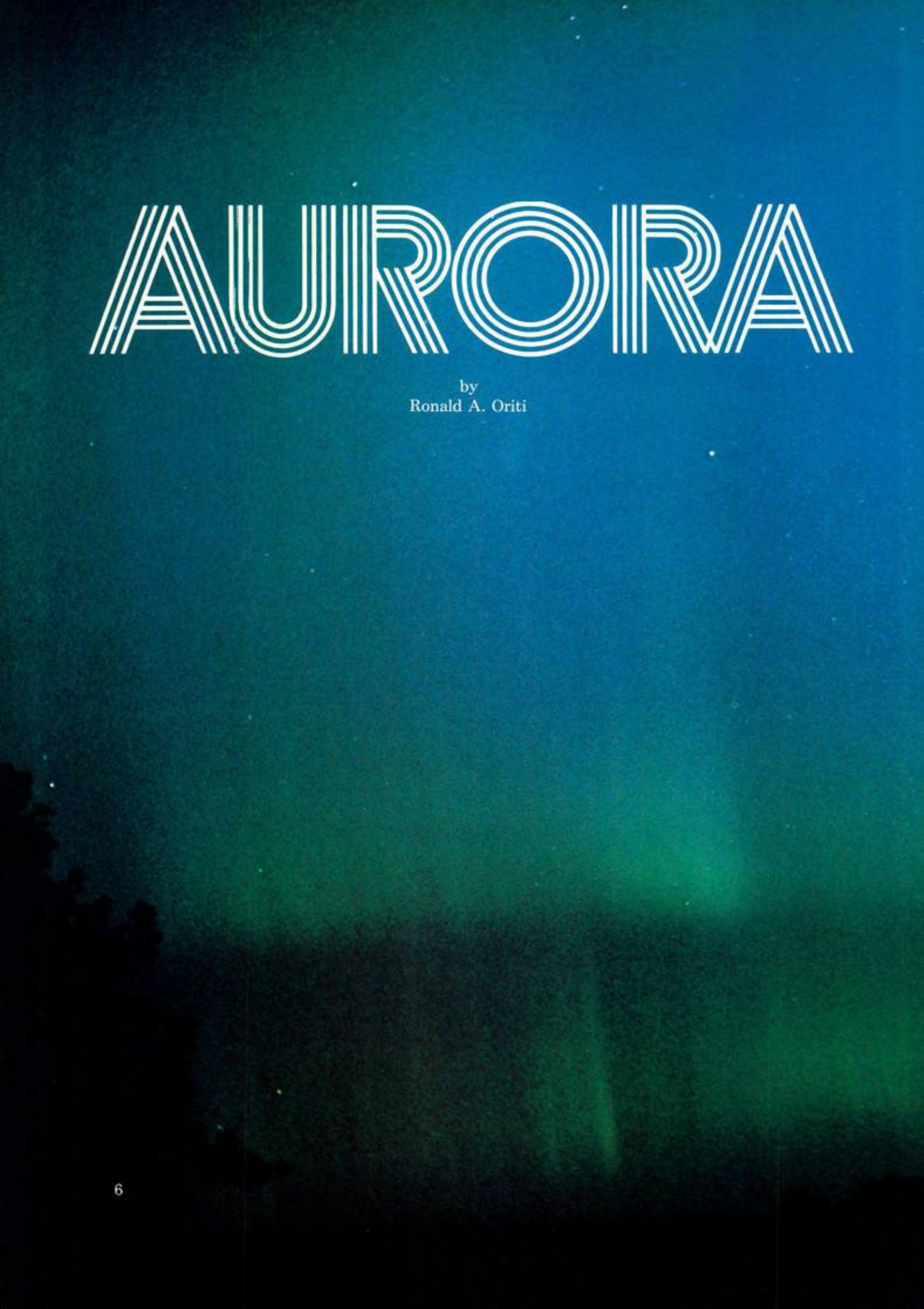


AURORA

by
Ronald A. Oriti

Aurora Borealis is one of the most spectacular sky shows in nature. Shimmering and dancing, the colored lights produce a celestial fantasia the viewer will long remember.

One of the finest descriptions of the northern lights in literature is the following account by John Muir in **Travels in Alaska:**

"Gazing into the starry sky and across the sparkling bay, magnificent upright bars of light in bright prismatic colors suddenly appeared, marching swiftly in close succession along the northern horizon...though colorless and steadfast, the aurora's intense, solid white splendor, noble proportions, and fineness of finish excited boundless admiration. In form and proportion it was like a rainbow, a bridge of one span five miles wide, and so brilliant, fine and solid and homogeneous in every part. I fancy that if all the stars were raked together into one window, fused and welded and run through some celestial rolling-mill, all would be required to make this one glowing white colossal bridge."

In the early 1900s, Norwegian astrophysicist Carl Stormer explained that aurorae were due to protons, electrons and nuclei of some heavy elements given off by solar flares. These charged particles travel with speeds of hundreds and even thousands of miles per second, reaching Earth in about a day or so. Stormer proposed that particles were captured by Earth's magnetic field and followed spiral paths along its magnetic lines of force.

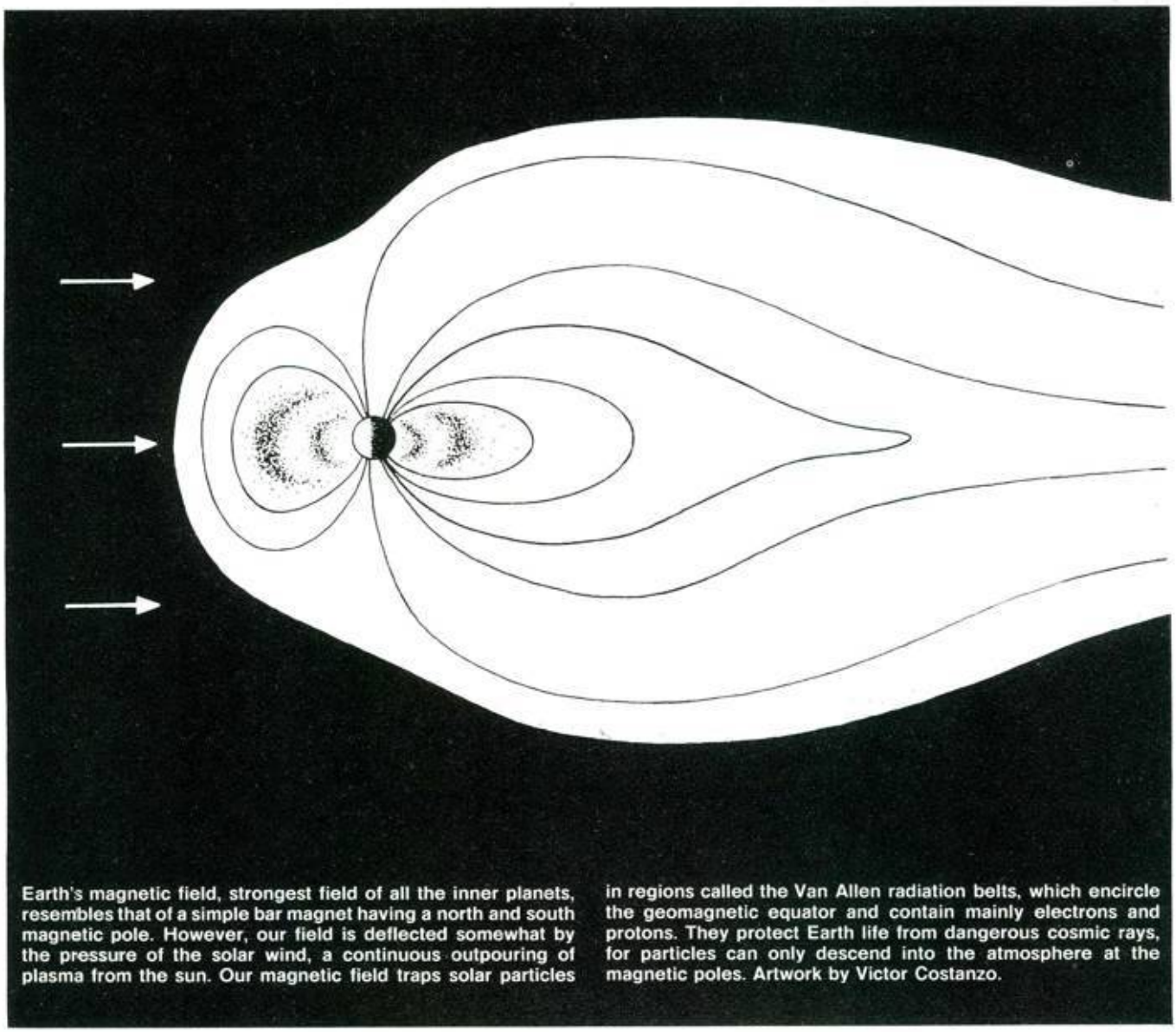
In 1956-57, Willard H. Bennett, head of the atomic physics branch of the United States Naval Research Laboratory, developed a model recreating conditions which produce aurorae. The "Stormertron" contained a glass sphere representing Earth, and a magnet providing an equivalent of Earth's geomagnetic field. The sphere was placed in a sealed vacuum. Mercury vapor was added, and a beam of electrons was then directed at the model Earth. The shielding magnetic field either deflected the electrons away or toward the globe, depending on their angle of approach. The mercury vapor glowed like miniature aurora, defining a radiation belt around the model Earth.

The experiments showed electrons being deflected to the night side of Earth — explaining why the aurora is essentially a nighttime phenomenon.

In near infrared and visible light, the aurora appears quite dramatic from space. Auroral activity frequently displays eddylike currents hundreds of miles long. Several weather satellite photographs, each taken near local midnight, were overlaid to form this composition. The glow of United States' cities appear at latitudes below the aurora. United States Air Force photograph.

Caption for Page 6

A vivid aurora, as seen from Wisconsin on Aug. 4, 1972, appears in this 13 second exposure. A Minolta SRT-101 recorded the dancing curtains on High Speed Ektachrome pushed to ASA 400. A rigid tripod mounting is mandatory for such photography.



Earth's magnetic field, strongest field of all the inner planets, resembles that of a simple bar magnet having a north and south magnetic pole. However, our field is deflected somewhat by the pressure of the solar wind, a continuous outpouring of plasma from the sun. Our magnetic field traps solar particles in regions called the Van Allen radiation belts, which encircle the geomagnetic equator and contain mainly electrons and protons. They protect Earth life from dangerous cosmic rays, for particles can only descend into the atmosphere at the magnetic poles. Artwork by Victor Costanzo.

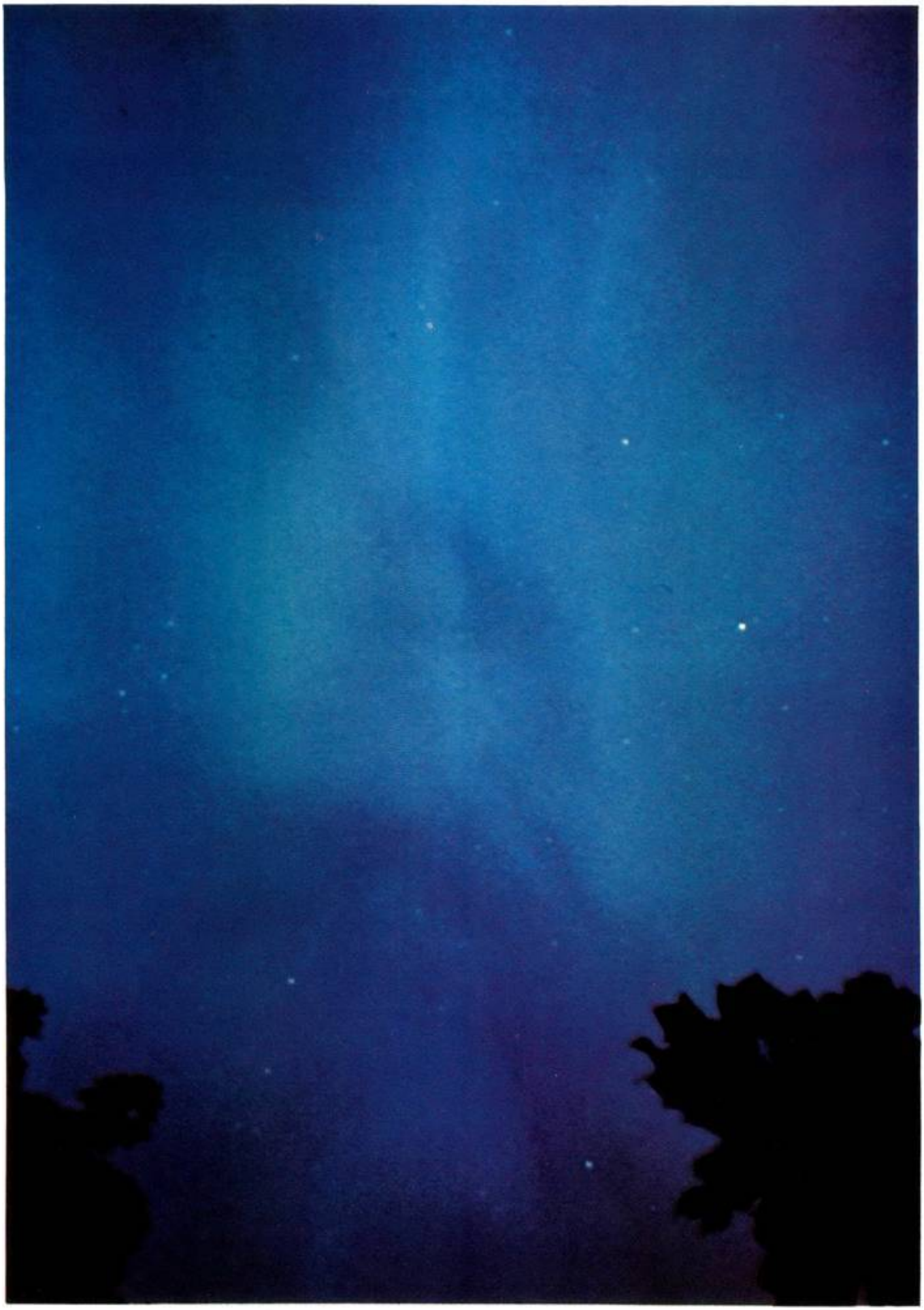
Although Stormer demonstrated how a magnetic field can trap charged particles and suggested that Earth's field acted in this way, it still came as a surprise when — in 1958 — rocket-borne instruments designed by American physicist James A. Van Allen detected two extensive belts of charged particles. The Van Allen belts (as they are now known) encircle the geomagnetic equator, and contain mainly electrons and protons. Today astronomers believe there are not really two radiation belts, but one great belt filled with particles.

There are zones of particles differing in energies. The inner zone — centered about 2,000 miles above Earth — contains highly energetic protons, while in the outer zone (12,000-15,000 miles above), electrons possess high energy. The region between these two zones — called the *slot* — contains approximately the same numbers of electrons and protons per unit volume as found in the other regions. However, here they are less energetic.

The particles in the Van Allen belt move in an unusual spiral fashion, oscillating from pole to pole in a few seconds. They also drift around Earth in about one hour. The point above the auroral zone where a particle changes direction and begins oscillating toward the opposite pole is called the *mirror point*. When the particle is spiraling in at an angle, it will escape and penetrate the atmosphere instead of bouncing back into space. The interaction of such particles with the atmosphere produces the aurora.

Experts first thought magnetic storms produced by solar flares poured electrons from the outer Van Allen belt into the atmosphere. It has since been found that the particles producing the aurora are even more energetic than those in the outer belt. Earth's magnetic field must in some way

An intense blue aurora lights up the morning skies over Rochester, N.Y. in this July 6, 1974 photograph. A Minolta SRT-101 equipped with a 35mm lens at f/2.8 captured the display in a 20 second exposure. Photograph by Thomas P. Wilhauck.



AURORA OR FIRE?

During a World War II blackout in Los Angeles, residents saw the bright glow of an aurora above the surrounding mountains. Never before had they seen such a phenomenon and concluded that it was the light of a forest fire. They reacted in a logical but ultimately embarassing way: They called the fire department!

A similar mistake was made during the reign of the Roman emperor Tiberius (between 42 B.C. and 37 A.D.) when something resembling a distant fire appeared over the colony of Ostia on the outskirts of Rome. A legion of men ran to the rescue, only to find the sky glowing from an unusual auroral display.

While aurorae have been mistaken for fires, the opposite also occurs — fires are mistaken for aurorae. In 19th century Germany, a guest was on his way to an evening party near Frankfort where he was expecting to meet Herr von Radowitz, a verbose amateur natural philosopher. A burning barn caught his eye; he stopped his carriage, assisted the people, and waited until the flames were nearly extinguished. When he arrived at the dinner party he found Herr von Radowitz expounding on terrestrial magnetism, electricity, and related phenomena. Radowitz and the party had just come down from the roof where they had been observing an auroral display. "Have you seen the beautiful Aurora Borealis?" Radowitz asked. "Certainly," the guest replied, "I was there myself; it will soon be out!" Radowitz was silent some 10 minutes; then took up his hat and quietly disappeared.

accelerate electrons to very high energies and deflect them more directly into Earth's polar regions where our planet's magnetic axis is located.

On the average, auroras tend to occur more frequently in two zones — around Earth's north and south geomagnetic axes. These approximately circular zones average about 20 to 25 degrees in radius, and auroral displays appear to occur simultaneously in both zones.

Auroral zones show strong seasonal variations. Maximum displays occur near the time of the spring and fall equinoxes. They also show variations coinciding with the 11 year sunspot cycle. At times of sunspot minimum, the auroral zones shrink around the geomagnetic poles. As sunspot maximum increases, the auroral zones enlarge and move toward the equator. Two years after sunspot maximum, auroral youth reach their greatest extent.

The finest displays occur at an altitude of about 65-70 miles above Earth. Measurements from rockets launched during auroral activity indicate that at this height, the atmosphere over the auroral zones is much warmer than over the equator. This heating effect has been attributed to energy released by collisions with high speed electrons. The lower limit for auroral formation is about 40 miles, while the upper limit is over 600 miles. At 600 miles the atmosphere is almost nonexistent, but the few remaining atoms still glow.

Interaction of the particles with Earth's atmosphere is not completely understood, though the basic principle behind production of aurora is familiar. A rarified gas can glow by sending an electrical discharge through it; the color or wavelengths of emitted light depends on the composition of the gas. Light from only certain wavelengths is given off, and which lines or colors are brightest depends on the energy of the electrons.

An aurora occurring on Aug. 4, 1972 produced a spectacular display of color when recorded for 20 seconds on High Speed Ektachrome. The photo was taken with a Leica M-3 camera and a 50mm lens at f/2. Photograph by Ronald Parmentier.

Captions for pages 12 & 13

Upper left

A brilliant blue curtain aurora silhouettes a fir tree in this 10 second exposure. Aurorae at high altitudes show a bluish tinge due to ionized molecular nitrogen. A standard 50mm lens recorded the aurora on High Speed Ektachrome film. Photograph by Von Del Chamberlain.

Upper right

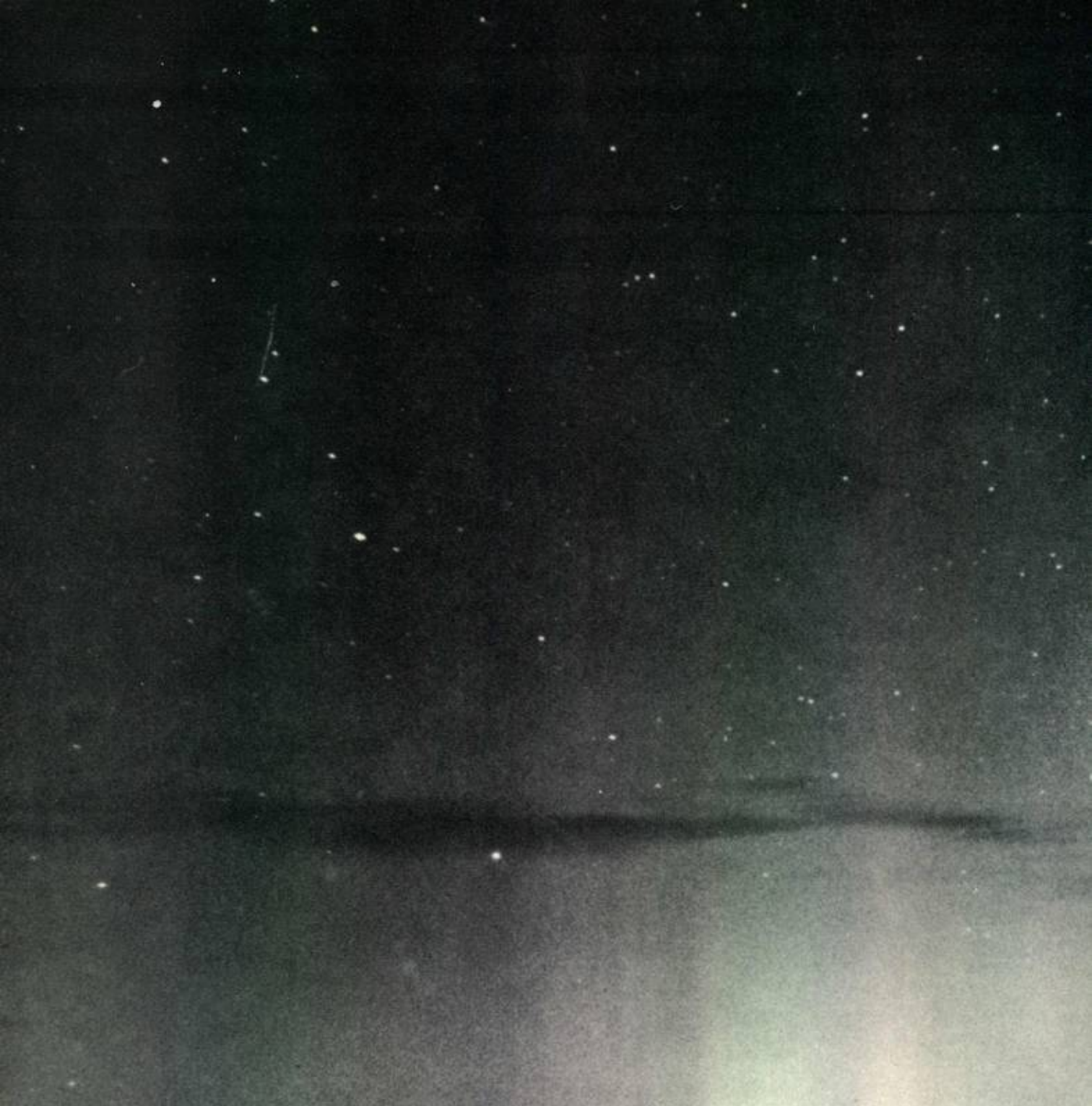
Flickering arcs filled over 70 percent of the sky on the morning of July 6, 1974. The display was the most intensive aurora occurring that year. Near the bottom of the auroral curtain appears the double star Mizar, in Ursa Major. Photograph by Thomas C. Bretl.

Lower left

A yellow-green curtain shimmers in front of the constellation Cassiopeia, easily identified by its "W" shape. Oxygen glowing at low pressures usually produces such colors. This 30 second exposure was recorded on High Speed Ektachrome. Photograph by Von Del Chamberlain.

Lower right

During August and September 1972, extremely spectacular aurorae were visible over much of the United States. The sun was near the peak of its 11 year solar cycle that year; thus Earth was bombarded with more cosmic rays than usual, which provided the energy for producing aurorae.



Spike patterns assemble a curtain in this 30 second exposure. The photographer describes the color of this particular aurora as pale green. An f/2 normal lens and Tri-X Pan film were used. Photograph by Tom Harris.

Studies of auroral spectra indicate that colors result from glowing oxygen and nitrogen (the principal constituents of Earth's atmosphere). Atomic oxygen at low atmospheric pressures produces a yellow-green light, and at extremely low pressures (high altitudes) it emits red light. Molecular nitrogen and ionized molecular oxygen also glow red. High altitude auroras (above Earth's shadow) which receive sunlight show a bluish or purplish tinge due to ionized molecular nitrogen. The color of any display is usually the result of a blending of spectral lines. The intensity of any particular line causes one color to predominate.

The most intense auroral displays appear to result from high-energy electron beams. Protons also produce auroras, but because they are usually less energetic, these events are mostly diffuse and short-lived.

The finest auroral displays usually follow a predictable sequence. At first a faint green glow appears in the northern sky, gradually taking on the form of a pale arc whose ends rest on the horizon. The arc slowly moves up the sky, brightening as it rises. Other arcs may form and march up the sky — some of them reaching the zenith or even going beyond to the southern horizon. Eventually the bands begin breaking up and the aurora enters a

more active and varied phase. The bands become thinner, developing rays and folds that form dancing curtains and draperies of colored light. Rays may dart from the curtains as waves traverse the lengths of the bands. This phase may last only minutes or continue many hours.

The most dramatic shapes and forms herald the end of an especially intense display. Collections of small pulsating curtains finally evolving into soft billowy clouds, brighten and fade in a matter of seconds. These are usually the last forms to fade away. However, new sequences may follow, and the auroral display may continue until dawn blots it out.

During strong displays people have reported hearing crackling and hissing noises. These are called anomalous sounds since they do not result from the aurora itself. Earth's upper air is too thin to be an efficient conductor of sound waves. Instead, these sounds seem to originate from radio waves emitted by the aurora, or from electric currents induced near the observer by the changing magnetic fields.

The ancient Vikings or Norsemen thought the northern lights were the spirits of fallen warriors being carried to Valhalla by the Valkyries, daughters of the god Odin. In Valhalla (the home of the gods), the spirits would receive new bodies, and remain in paradise for the rest of eternity.

If we could devise a paradise for 20th century man, we might well arrange for an occasional display of the magnificent northern lights.

STARSPOTS ON BETELGEUSE

Of all the sciences, astronomy most heavily depends on visual information. Both in space and time, stars, galaxies and quasars are out of touch from our other senses. Astronomers in particular have relied heavily on photography in analyzing distant objects. However, over the years observers have had to patiently cope with many of photography's failings — including restrictions of film sensitivity, resolution, exposure times and many other variables.

Now astronomers at Kitt Peak National Observatory in Tucson, Ariz. are combining the best of two astronomical analysis methods — time-honored photography and electronic power of the modern large computer — to produce an exciting new imaging system. Heart of the new instrumentation is the Interactive Picture Processing System (IPPS), which allows astronomers to accentuate selected areas — such as the faint outer regions of distant galaxies — by simply altering contrast and color controls on the IPPS. In this way, an experimenter can immediately analyze the full range of visual information available.

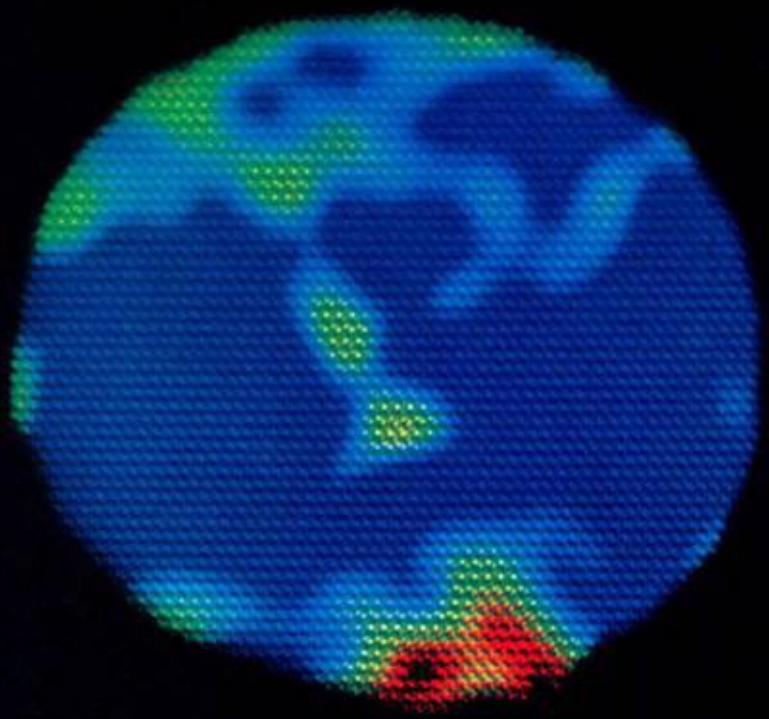
To use the IPPS, an astronomer converts a photograph, television picture, or even radio data into a digitally encoded image on magnetic computer tape. The tape is then processed through the main observatory computer, and directed through a minicomputer to the digital picture display for image enhancement and analysis.

With the IPPS, an astronomer can study a computer picture — in vivid abstract colors if he wishes — much the same as a photograph. The visual data can also be smoothed, further enhanced, or even compared with other views of the same scene instantly. An experimenter can modulate combinations of blue, green and red light to produce true color or false color images. Monochrome images can also be displayed in a form of color coded contour map.

What object is the Kitt Peak system looking at? "We're interested in everything," comments IPPS researcher Donald Wells. "It's a very versatile system, capable of handling a wide variety of topics." Two examples of IPPS imagery are presented here.

Page 19 reveals "starspots" (so-called by Kitt Peak astronomers for their similarity to spots on our own sun) on the surface of the red star Betelgeuse. Betelgeuse (Alpha Orionis) is a cool, supergiant star 60,000 times larger than our sun, and 500 light-years away. By using short exposure times, Kitt Peak astronomers were able to minimize atmospheric degradation while "freezing" the star's image. An image intensifier was used to amplify the brightness of far-off Betelgeuse. The photographs were then processed by the observatory computer

This photograph (picture opposite page) shows a colorful representation of Betelgeuse (Alpha Orionis) as intensified by the new Interactive Picture Processing System (IPPS) which allows astronomers to accentuate selected areas of a photograph by simply altering contrast and color controls on the IPPS. Kitt Peak National Observatory photograph.

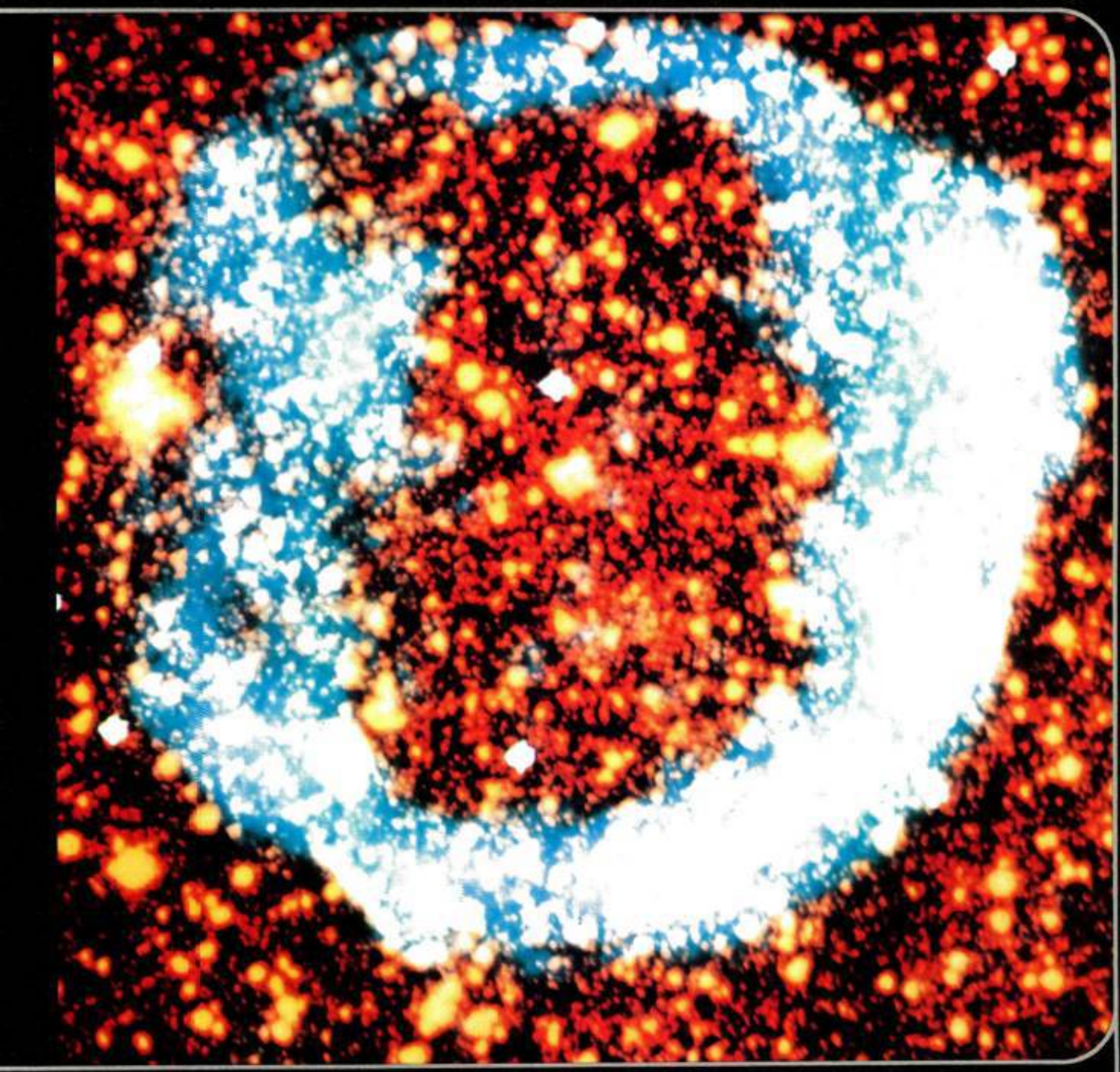


An interacting pair of galaxies [ESO (B)—138, 29, 30] is receding from us at 3,000 miles per second. The IPPS enhancement of features will unite human perception and computer capabilities. Kitt Peak National Observatory photograph.

to help undo any remaining blur, allowing the Kitt Peak investigators to recover actual images of the star. The large scale structures visible are thought to be huge regions of hot and cold gases, similar to convective features observed in our sun. The disk is about 0.08 arc seconds in diameter. (In comparison, a good 60mm refractor has a resolution of about 1.90 seconds of arc.)

This page shows a pair of interacting galaxies. Accentuated here are the faint outer regions of the two galaxies, along with the long "tail" connecting the pair. Kitt Peak scientists believe that the outer ring around the larger galaxy may be composed of young stars recently formed from a disk of neutral hydrogen surrounding that galaxy. The star formation may have been triggered by the second galaxy passing through the first.

This pair of galaxies is found in the southern hemisphere and is known as ESO (B) - 138, 29, 30. Scientists estimate they are receding from us at a velocity of 3,000 miles per second, and may be about 300 million light-years away. The huge ring surrounding the larger of the two galaxies appears to be about 180,000 light-years across, and is similar in size to our own Milky Way.

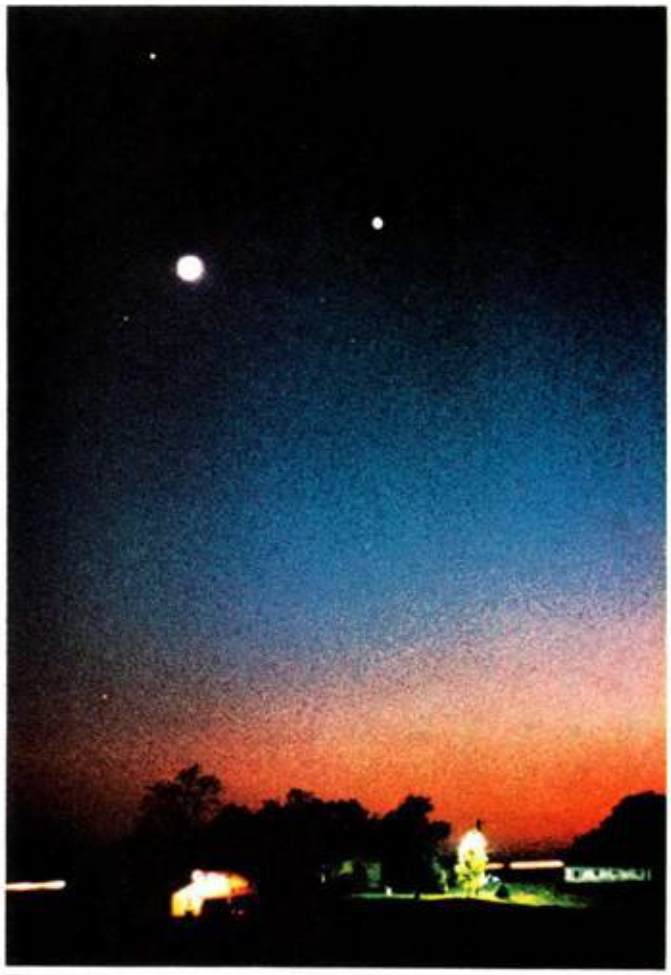


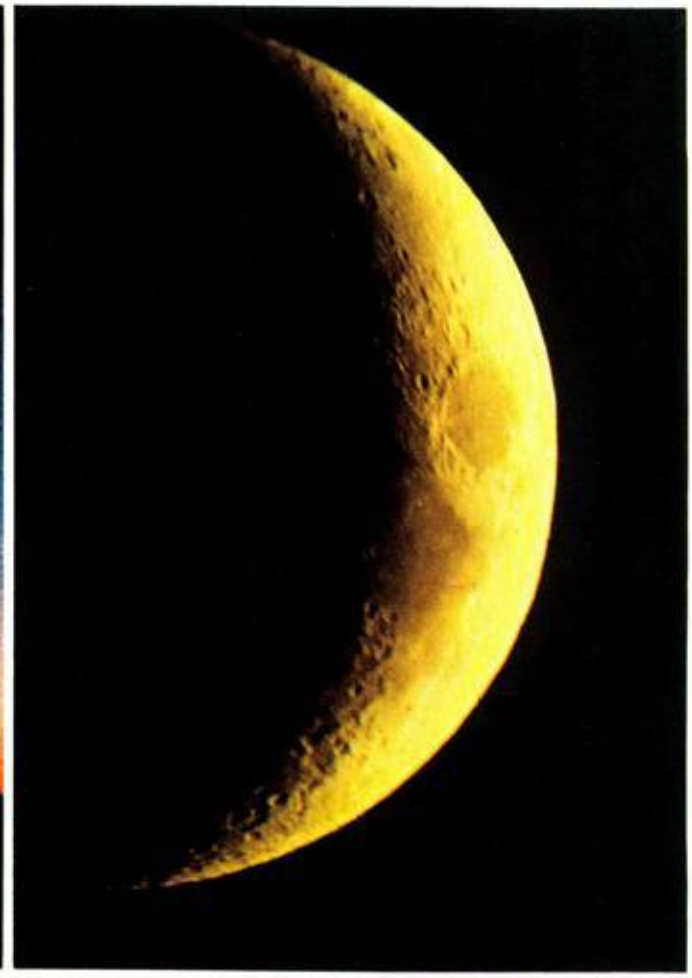
This colorful supernova remnant, converted from radio data into visual data by the IPPS, was one of the preliminary tests done with the new optical enhancement system. Kitt Peak National Observatory photograph.

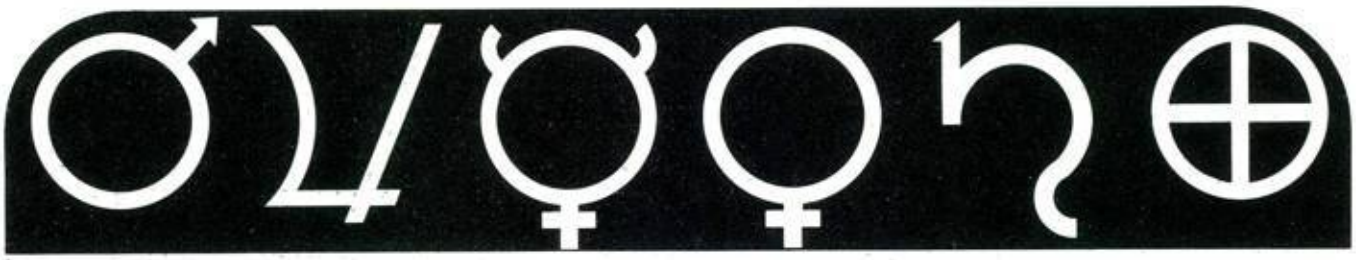
Some Kitt Peak scientists believe that this kind of imagery provides an important psychological advantage. "What we're after with the IPPS," says Wells, "is to use astronomers' ability to see the data, and then guide the computer in analyzing this data by means of a visual reference." Wells believes that instrumentation such as the IPPS will bring about a successful blending of human perception and the information handling power inherent in large digital computers.

The IPPS provides such an advantage in data analysis that many scientists feel it will become an auxiliary instrument most in demand by the hundreds of scientists visiting Kitt Peak yearly. According to Dr. Stephen Strom of Kitt Peak, the IPPS may someday rival even the new giant four meter (158 inch) Mayall telescope in Chile with requests from potential users.

During the next several months Kitt Peak researchers plan to continue experimenting with the IPPS system, utilizing a large variety of photographs and telescopic data. In about a year, astronomers allocated observing time at Kitt Peak will be able to utilize this new, colorful window to the universe.







Jupiter's All There Is, Folks!

The moon, Saturn (upper left) and Venus (right) were joined by Mercury (above the horizon, far left) in the evening sky over Montgomery, N.Y. on May 14, 1975. The four were photographed with an Exakta VX11B camera through a Zeiss Flektagon 35mm lens. The GAF 500 film was exposed at f/2.8 for two seconds, recording a vividly red horizon. Photograph by Joseph Lehrer.

The beauty of the five day old moon on the night of July 11, 1975, prompted this photograph shot through a six inch, f/6 homemade telescope. The afocal method was used with the camera held on a stationary tripod to eliminate vibrations. The High Speed Ektachrome, exposed at 1/15 second, was pushed to ASA 400. Photograph by Sharon Hoveln.

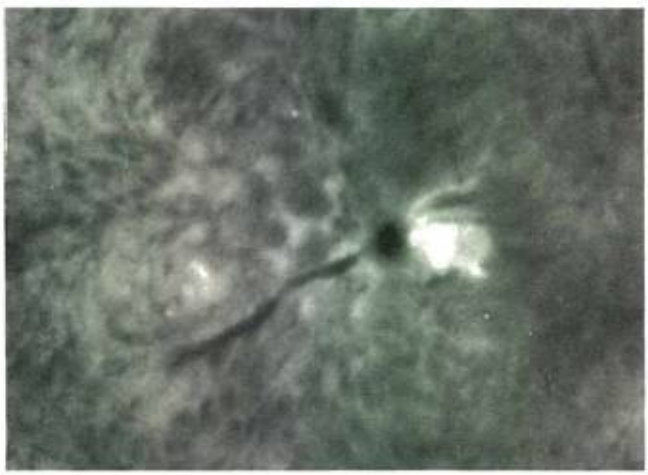
A typical greenish-tinged aurora, spiking dramatically through the constellations Lyra and Draco, occurred on Oct. 12, 1974 and was photographed near Hibbing, Minn. High Speed Ektachrome exposed between 10 and 15 seconds through a Minolta 102 camera equipped with an f/1.4 lens at full aperture recorded this special event. The film was developed at ASA 400. Photograph by Kevin Milani.

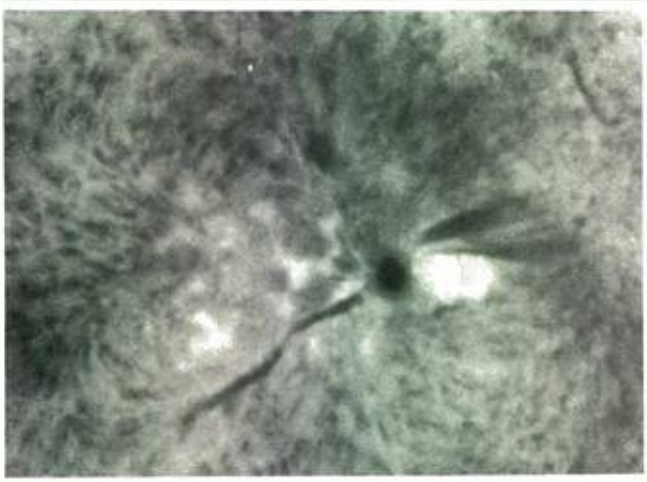
October is the month for observing Jupiter. The giant, colorful planet dominates the sky all night, making it an ideal target for astronomy enthusiasts. In the early morning hours Venus and Mercury follow Jupiter as a spectacular planet pair.

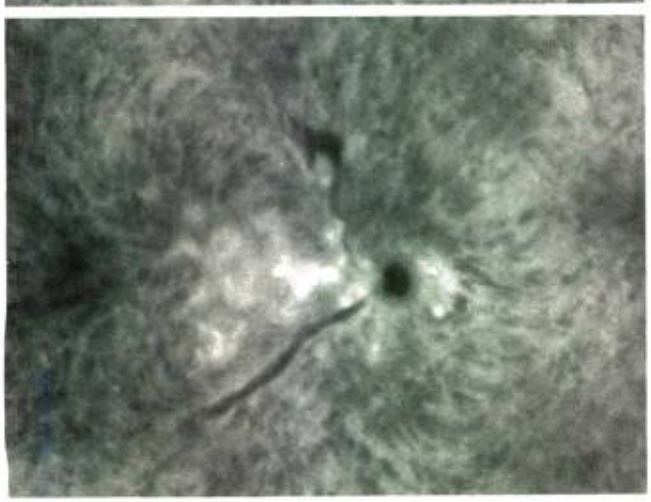
Mercury

During the last half of October, Mercury is visible as a morning star. Preceding sunrise by about 1-1/2 hours, the innermost planet increases in brightness from +1.5 magnitude on the 15th to -0.7 by the 30th. Over this same period, Mercury's disk grows from a 30 percent illuminated crescent to a 75 percent gibbous phase.

On Oct. 19 Mercury reaches perihelion, skimming within 28.5 million miles of the sun. Mercury begins the month at a distance of 65 million miles from Earth, and as the speedy planet sweeps past its







closest approach to the sun, its distance from Earth increases to 103 million miles at month's end.

Venus

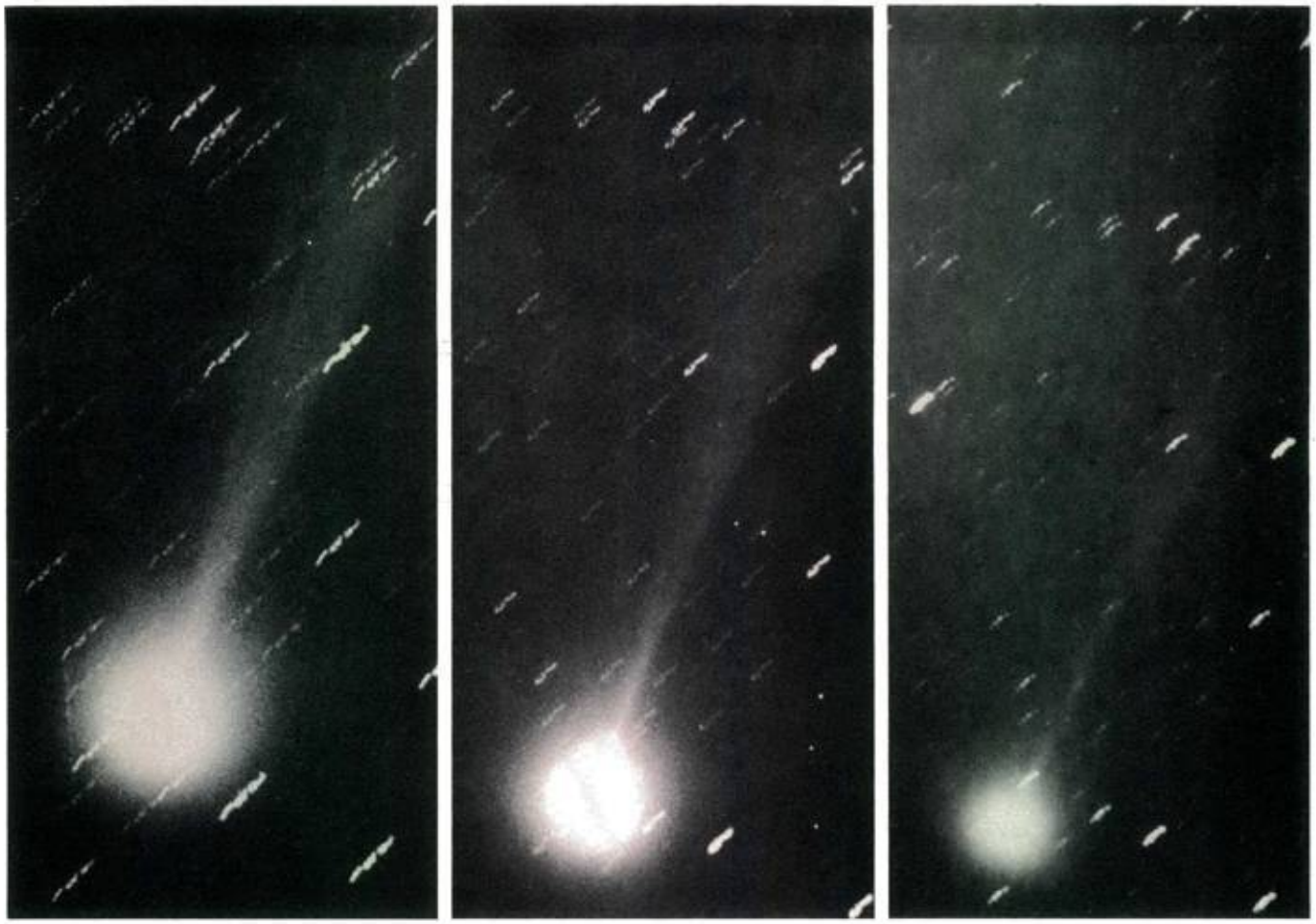
Venus reigns as master of the morning sky all month. Rising three hours before sunrise, Earth's sister planet reaches greatest brilliancy on the 3rd — a spectacular -4.3 magnitude. Venus exhibits a modest 30 percent crescent on that date, but is a relatively close 39 million miles from Earth. As Venus recedes to a distance of 58 million miles by the 31st, its magnitude drops to -4.1.

SATELLITES OF JUPITER OCTOBER

1	10234		16	3024	
2	3024		17	32104	
3	3201		18	32104	
4	34120		19	30142	
5	4012		20	14023	
6	4103		21	42013	
7	42013		22	4103	
8	41023		23	4012	
9	43012		24	43210	
10	3420		25	4320	
11	32140		26	43012	
12	30142		27	41023	
13	10234		28	2013	
14	20134		29	1034	
15	10234		30	0124	
			31	31204	

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 2 a.m. (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0=Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

This photo sequence, captured through a Carson Skyspear filter, shows the dramatic development of a solar flare on the surface of the sun. The filter was mounted on a Celestron 14 telescope, and the sequence was photographed with a Laborec camera at the first focus (see Photography in Astronomy, page 33). Exposure time to capture this sequence was 1/8 second. Photographs by Ed Hirsch.



Comet 1975h showed distinct tail development and obvious movement as it sped through the sky in late July. All three exposures were taken on the night of July 29, 1975 at the prime focus of a home built eight inch f/5 Newtonian reflector on 103a0 and Tri-X films. Exposure times were 35, 20 and 17 minutes respectively. The comet's movement relative to the background stars is obvious, particularly near the nucleus. The object was in the constellation Draco, approaching Ursa Major. Photographs by Bob Kimmel.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Oct. 2	1	2:59 a.m.	5:10 a.m.
3	1	9:27 p.m.	11:39 p.m.
6	2	2:00 a.m.	4:40 a.m.
9	1	4:54 a.m.	7:05 a.m.
10-11	1	11:22 p.m.	1:34 a.m.
13	2	4:37 a.m.	7:16 a.m.
15	3	9:04 p.m.	11:37 p.m.
16	2	5:55 p.m.	8:35 p.m.
18	1	1:17 a.m.	3:28 a.m.
19	1	7:46 p.m.	9:57 p.m.
23	3	1:06 a.m.	3:38 a.m.
	2	8:32 p.m.	11:11 p.m.
25	1	3:12 a.m.	5:24 a.m.
26	1	9:41 p.m.	11:52 p.m.
30-31	2	11:09 p.m.	1:47 a.m.

1=Io
2=Europa
3=Ganymede
4=Callisto

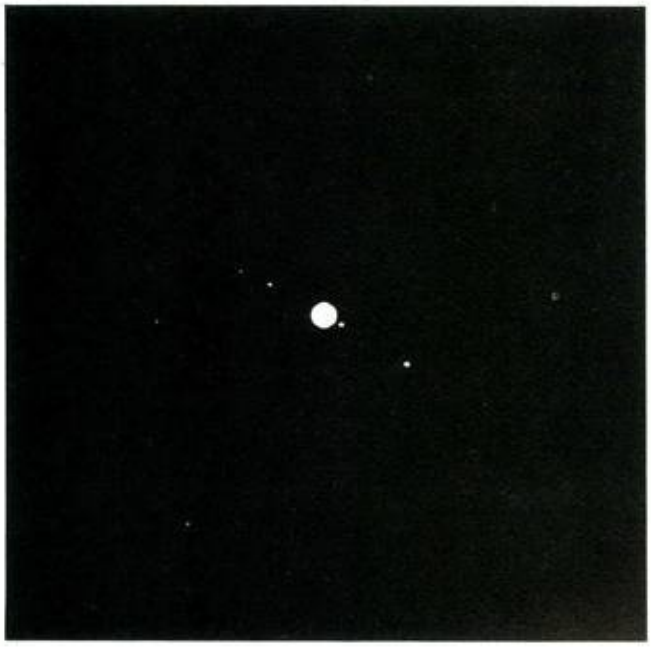
Mars

The red planet now rises late in the evening and can be found between the constellations Taurus and Gemini. During October, Earth continues catching up with the slower moving Mars. At the beginning of the month, Mars lies 80 million miles away; that distance is reduced to 64 million miles on the 31st. Correspondingly, Mars' characteristic orange disk increases from 11 seconds of arc in diameter to 13 seconds, and grows in brightness from -0.2 to -0.7 magnitude.

Jupiter

The largest planet in the solar system is visible all night during October, rising on the eastern horizon at sunset. Jupiter is in opposition on the 13th, meaning almost all month it glistens at -2.5 magnitude — Jupiter's maximum brightness for 1975.

Comet Kobayashi-Berger-Milon was a popular subject for astrophotographers when it entered the solar system. This particular photo, taken from the Malibu (Calif.) Mountains when the comet was in the constellation Lyra, was exposed on 103aF film for 10 minutes in a Pentax body at the prime focus of a home built 4.25 inch f/5 reflector. Photograph by Michael R. O'Neal and Marvin J. Mayo.



A view of the Galilean satellites of Jupiter as seen at the prime focus of an Edmund six inch, f/8 reflector shows all four of the bright objects. High Speed Ektachrome exposed for three seconds in a Miranda G camera caught the elusive four. Photograph by James J. MacDougall.

On the 13th, Earth passes within 367 million miles of Jupiter. At opposition the planet's disk reaches a diameter of almost 50 seconds of arc at the equator and 46 seconds of arc at the poles. These two diameters reflect Jupiter's oblate shape, formed by the planet's dizzying 11 hour spin rate.

Astronomy enthusiasts' attention will be centered on Jupiter all month. Tips for observing this impressive planet are featured in Gazer's Gazette.

Saturn

The ringed planet is not nearly as ideally suited for observing this month as is Jupiter. Now more than 850 million miles away, Saturn's disk fills only 17 seconds of arc. Saturn rises around midnight and appears as a +0.5 magnitude object in the constellation Cancer.

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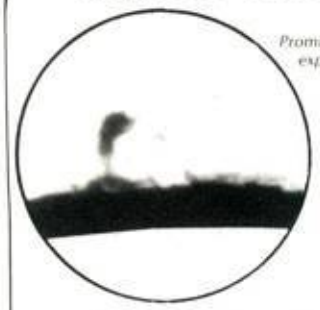

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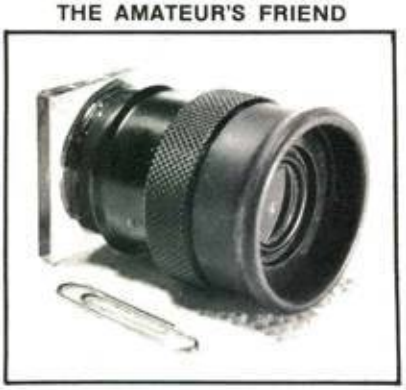

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Five Special Cameras Part 2

by
Leo C. Henzl Jr.

ASTRONOMY's August 1975 issue contained the first of a two part installment reviewing cameras for astrophotography. This month we review the DOAA Enterprises PLS astrocamera, and the AIC Miranda Laborec astrocamera. Due to its length, the section on cold cameras will appear soon as a separate installment.

The DOAA Enterprises PLS Astrocamera

High resolution astrophotography — photography of the sun, moon and planets at extreme magnifications — is far from easy. As a previous article pointed out (Photography in Astronomy, April 1975), odds against success include the rarity of excellent seeing conditions, irregularities in clock drive systems, and — certainly not least of all — shortcomings inherent in 35mm single lens reflex (SLR) cameras used for the purpose. Problems with shutter vibration and uncertain focus too often work against the photographer rather than with him — placing him at odds with his equipment.

What features can we incorporate in a camera design that will make high resolution photography a cooperative enterprise between photographer and equipment? Starting with a clean sheet of paper and ignoring conventional camera designs, we'd probably come up with something along these lines:

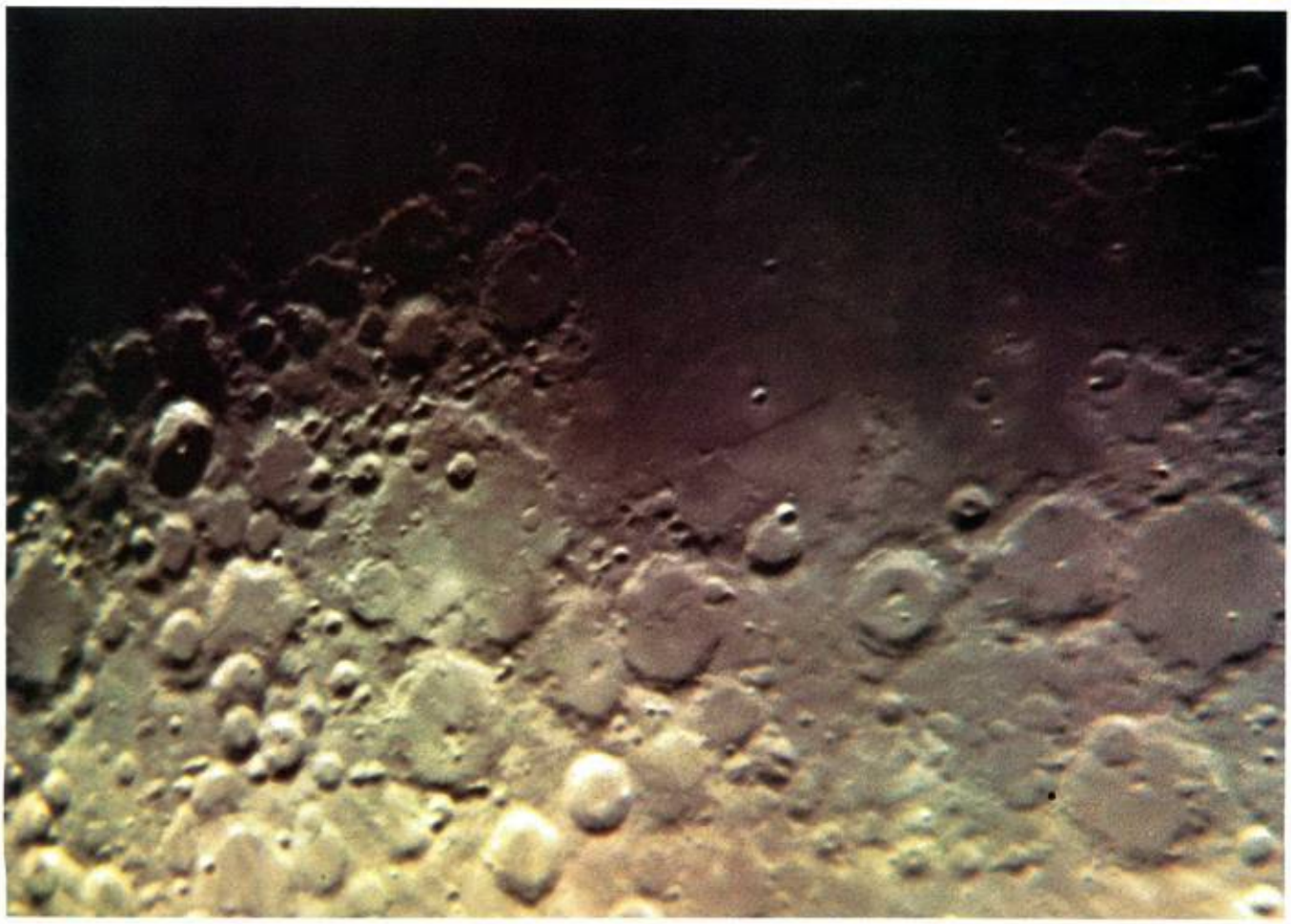
1) A brilliantly clear focusing system, which would allow monitoring the image right up to, and — well, why not? — even during the actual exposure. (This isn't possible, of course, with the moving mirror of the conventional SLR.)

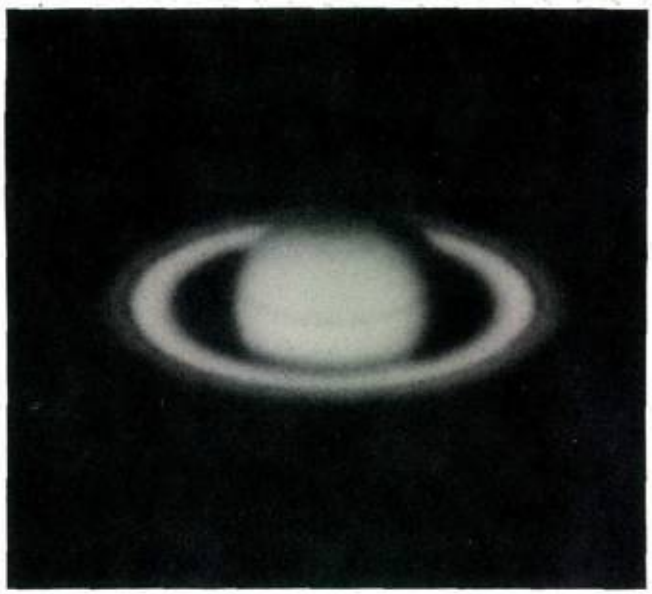
2) A totally vibration-free shutter mechanism.

3) A film transport that wouldn't disturb the telescope's pointing position — say, a rotary knob rather than the customary ratcheting lever.

4) Shutter cocking independent of the film transport — to permit fractional frame advances.

The lunar crater Plato (near the terminator) dominates this photograph taken with a DOAA Enterprises PLS astrocamera. The ability to focus precisely and to know when the exposure time is the best are important elements found in the PLS, as well as a vibration-free shutter for even finer exposures. This particular photo, taken through a Celestron 8 telescope on High Speed Ektachrome film exposed for 1/2 second at f/50, shows the outstanding detail that can be recorded at that proper moment of excellent seeing. Photograph by Leo C. Henzl Jr.





Much subtle detail is evident in the rings and disk of Saturn in this photo taken through a 14 inch Celestron telescope with the PLS camera. Exposure was seven seconds at f/90 on Kodak SO-410 film to attain subtle shading and contrast. Photograph by Leo C. Henzl Jr.

The Ring nebula was photographed with the Laborec at the first focus of a Celestron 14 telescope. Pictures of this quality demand perfect focus, achieved positively with the Laborec's clear focusing screen. Exposure was 20 minutes at f/11 on Kodak 103aF film. Photograph by Leo C. Henzl Jr.

(Why waste 36mm of unexposed film between each of those tiny planetary images?)

5) Positive-projection optics intended specifically for this purpose, without the compromise projection characteristics of most visual oculars.

6) An accessory system of colored filters to enhance the contrast of delicate planetary detail.

We'd also want the camera to be light and compact, and quick to get into operation. Then, after designing this gem, we'd probably add packaging commensurate with our inventiveness — a velvet-lined, hardwood storage case perhaps.

But someone has been here before us. What we've just described is the PLS astrocamera, distributed by DOAA Enterprises (also a supplier of drive correctors and other items of telescope electronics). The PLS is basically a modified Olympus scientific camera designed originally for photomicrography — an endeavor with many of the same requirements as high resolution astrophotography. Though the PLS bears a familiar label, it is completely unlike the now-popular Olympus OM-1 SLR — or, for that matter, any other camera you're likely to find on the shelves of your local photo retailer.

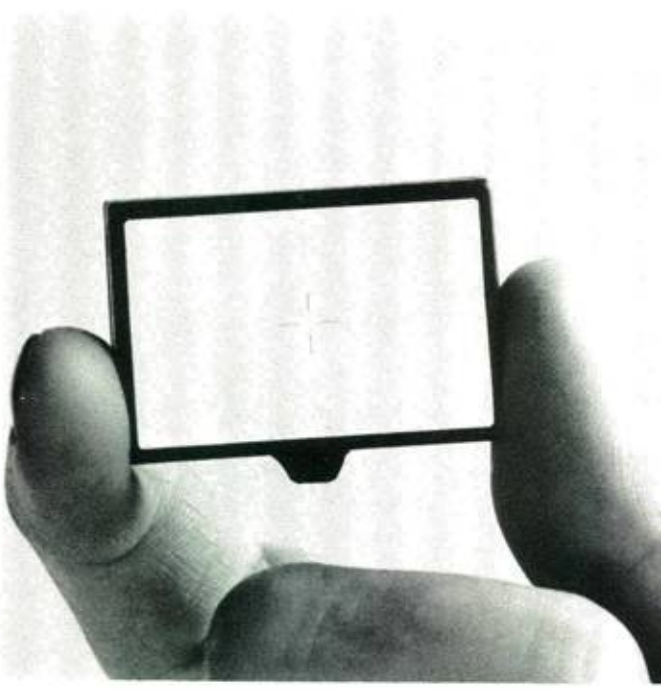
The PLS is technically a single lens reflex, insofar as the "taking" image is also used for viewing. But the generic similarity to other SLRs ends here. As the accompanying illustrations show, the PLS has a *beam splitter* in place of the familiar moving mirror.

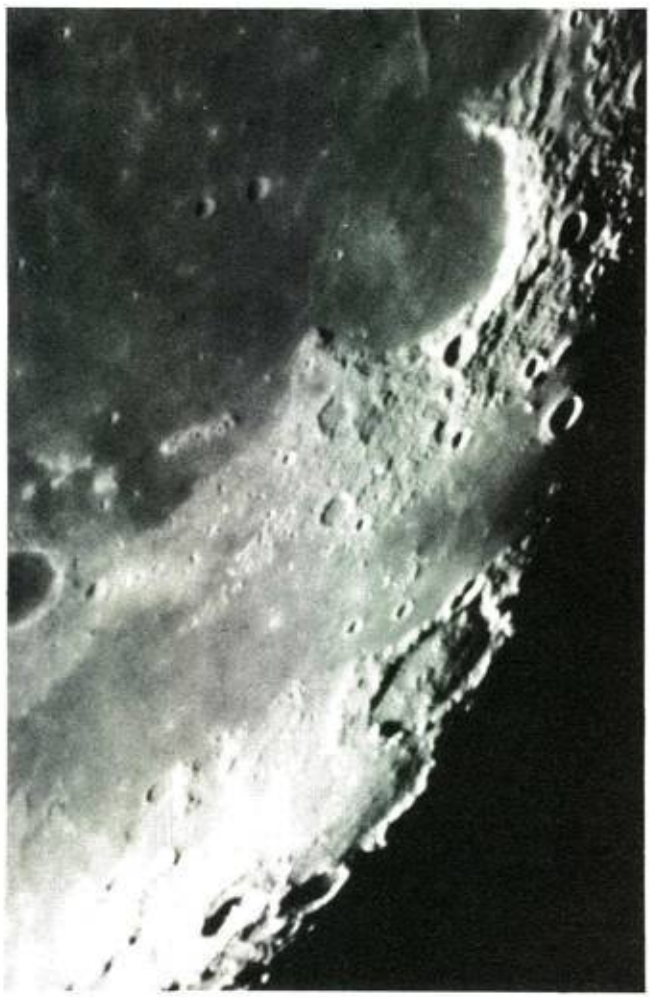
An external lever moves the beam splitter into any one of three different positions. In the first (used for focusing and viewing), 100 percent of the incoming light is channeled to a perfectly clear (aerial image) focusing screen for a viewing image fully as bright and crisp as that of a high power ocular. An etched reticle pattern on the focusing screen and helical diopter adjustment on the viewing eyepiece tailor the camera's focus to individual differences in eyesight.

In the second or shooting position, the beam splitter diverts 20 percent of the total light to the focusing system, while the remaining 80 percent passes unhindered to the film. Though somewhat dimmed, the viewing image is still far more brilliant and detailed than that of a conventional matte texture focusing screen — still bright enough, in fact, for accurate focusing. Think about that for a moment: you're actually able to monitor seeing conditions and drive action *while the shutter is open*. Obviously, the price of this capability is a 20 percent light loss at the film plane that can be accomodated by a slight increase in exposure time or reduction in image scale. Knowing exactly when to shoot is well worth this small price and is likely to prove much more valuable to the end result. Furthermore, as we'll see, the PLS has many other compensatory features.

Plato (right) and Copernicus (left) are visible in this photograph of the moon shot with the PLS camera on High Speed Ektachrome exposed for one second. A home built four inch Cassegrainian telescope was used with a 10 power eyepiece. Photograph by Gerald Persha.

The PLS camera reveals its ability to record that finest moment of seeing in this lunar photo. The Straight Wall (right) and the three distinctive craters Ptolemaeus, Alphonsus and Arzachel are dramatically captured on High Speed Ektachrome exposed for 1/2 second at f/50. The camera was mounted on a Clestron 8 telescope. Photograph by Leo C. Henzl Jr.





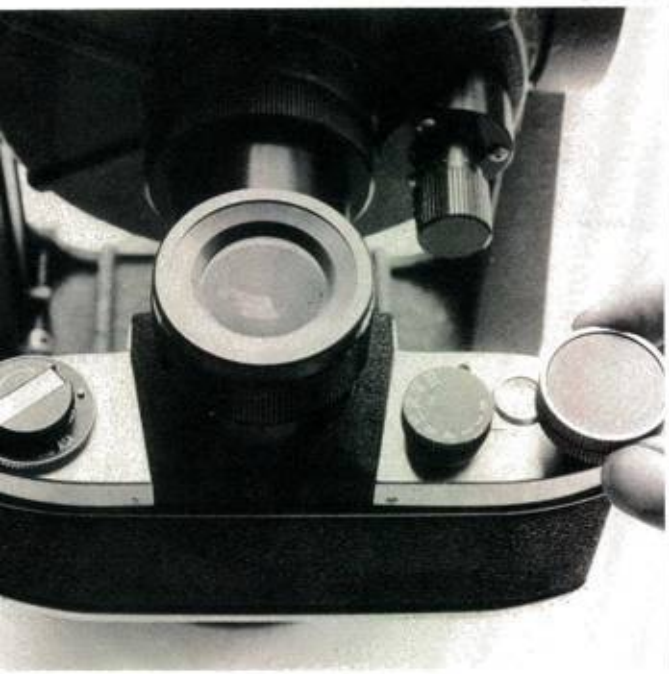
Plato and surrounding features are well shown in this photo with the PLS attached to a four inch homemade reflecting telescope. Exposure was two seconds at f/120. PLS features described in the text were instrumental in obtaining so unusually detailed a small aperture photo as this. Photograph by Gerald Persha.

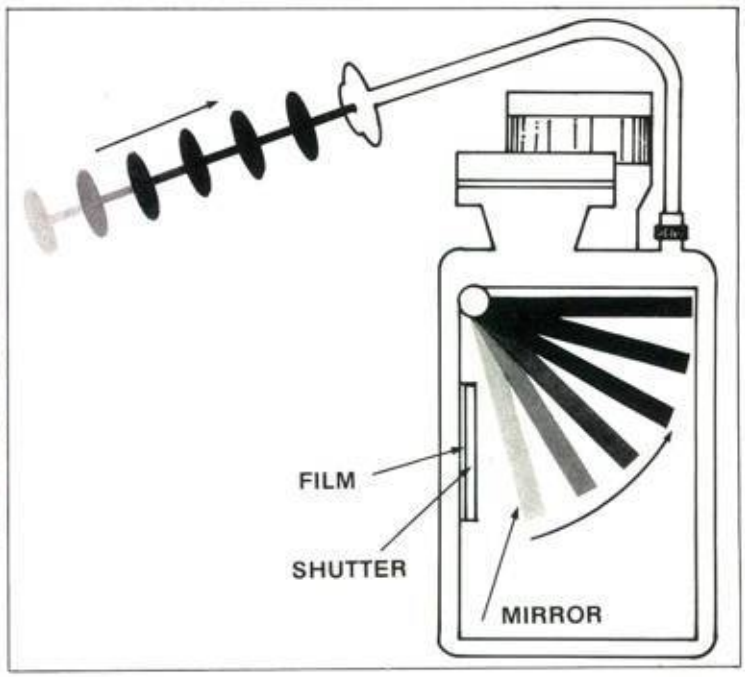
The beam splitter's third position diverts all the incoming light to an external port, designed to accept an exposure-metering device — useful in microscopy, but of little consequence here.

The PLS' shutter assembly is as unique as its imaging system. Above all, it is a *leaf* design — inherently quieter with more gentle recoil action than the usual *focal plane* shutter of the SLR. What's more, the entire shutter assembly is shock-isolated from the rest of the camera (and telescope) by a flexible bellows. The system proved completely effective in eliminating shutter vibration as a problem in astrophotography. No shutter vibration whatsoever was discernable even with extremely lightweight telescopes used in getting acquainted with the PLS.

Add to these assets a smooth rotary film advance with independent shutter cocking, and astrophotography assumes an entirely new aspect. In the language of industry, high resolution photography would be characterized as having "high productivity with low efficiency". Near-perfect seeing occurs rarely over most parts of the United States. When it does occur, it seldom lasts for long at a stretch. The idea, then, is to fire off as many frames as possible while conditions permit — in the hope that focus, clock drive and atmosphere will prove cooperative in at least one. Every moment spent in recentering, refocusing, reloading, prelocking an SLR's mirror, or waving a "black hat" in front of the telescope's aperture is counterproductive — especially if this wasted activity takes place during those few precious seconds of really superb seeing.

Planetary images generally occupy only a few millimeters of film. As a matter of fact, three or so will fit nicely onto a single 35mm frame. Thus, the PLS with its fractionary frame advance capability allows 100 or more exposures from a 36 exposure





A) The Laborec dismantled-focusing screen is at left, the magnifying viewfinder at right. Screen and finder may be removed or replaced in seconds for easy interchange with other Miranda systems. B) The Laborec's focusing screen — perfectly clear with a crosshair pattern — is employed to calibrate the viewfinder for individual differences in eyesight. C) Film is advanced with a rotary knob — which is much less likely to decenter a delicately balanced telescope than the common SLR's ratcheting lever. D) Much of the Laborec's convenience results from its integral shutter and mirror action. As the cable release is gradually depressed, the mirror slides gently out of the film path before the shutter trips. The mirror returns automatically to viewing position after exposure. Photographs by Leo C. Henzl Jr.

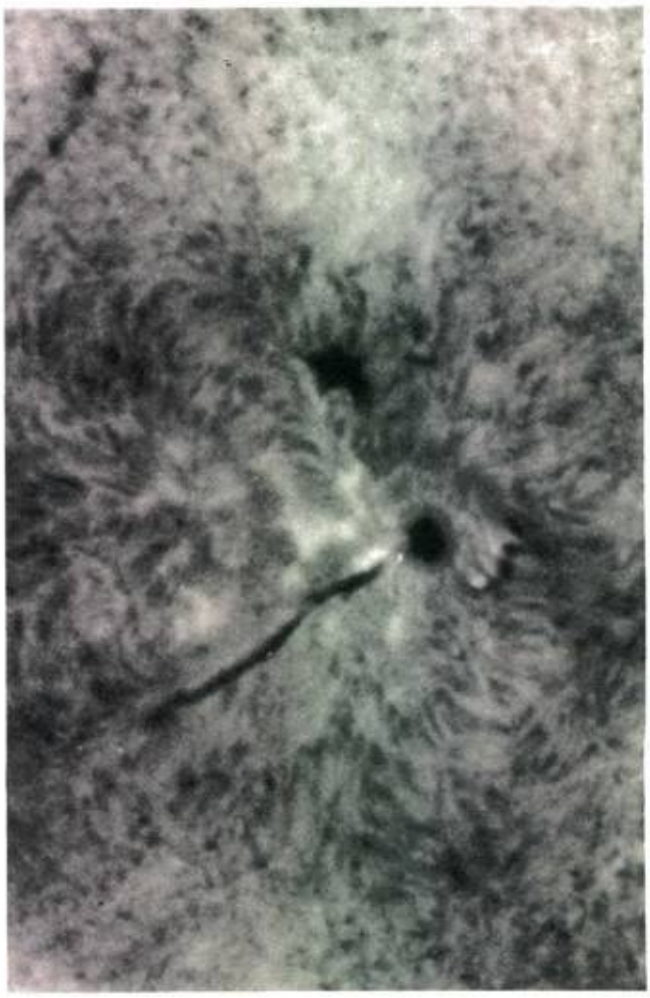
roll of film. Once the camera is loaded and attached to your telescope, seat yourself comfortably with remote shutter relase in hand, and wait for the proper moment — enjoying, all the while, a fine view of your subject.

All of this sophistication does have its price: $360 plus projection oculars, which are available in a variety of focal lengths. The PLS is also somewhat limited in versatility because it can be used only as a positive-projection camera. Thus, its applications are limited to planetary photography, and to close-ups of individual solar and lunar features. Since it is a specialized tool designed specifically for astrophotographic and microphotographic purposes, the PLS cannot be used at all for general photography. Within these confines, however, it would be difficult to imagine a more competent photographic tool.

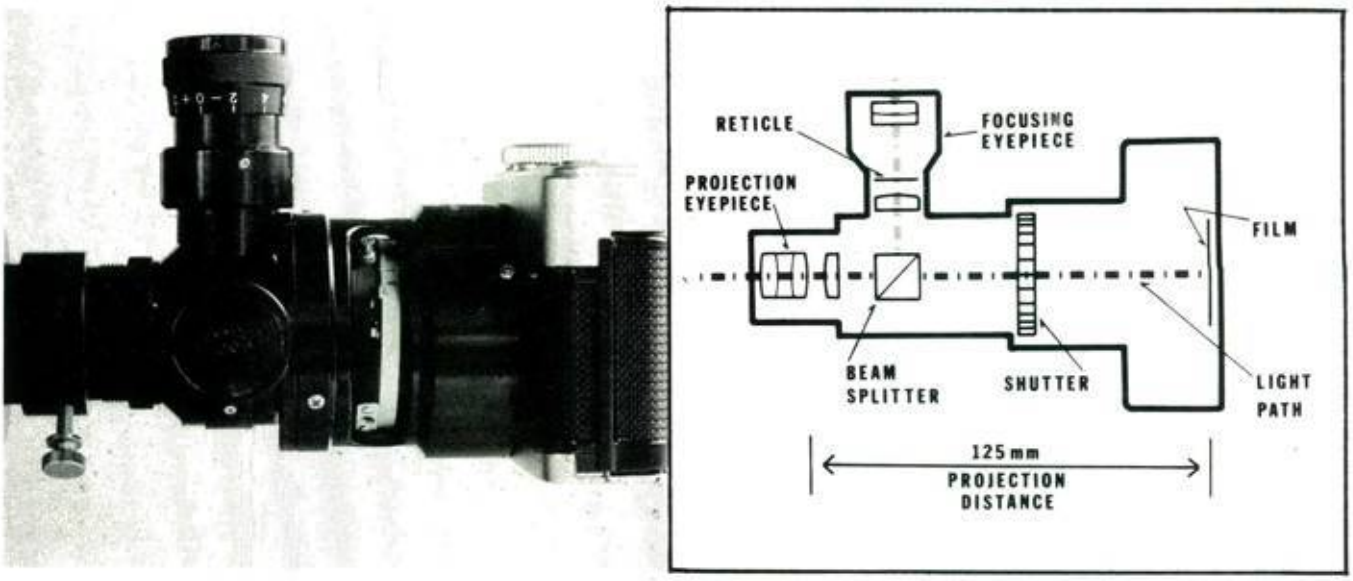
For additional information on the PLS, write to DOAA Enterprises, Dept. LA, 1912 W. 12-Mile Rd., Royal Oak, Mich. 48073.

The AIC Miranda Laborec Astrocamera

We can also thank photomicrography for still another capable camera for astrophotography — the AIC Miranda Laborec, distributed by R. T.



The beginning of the massive solar flare of July 2, 1975 was captured by the Miranda Laborec used in conjunction with a Celestron 14 and Carson Skyspear hydrogen-alpha filter. Kodak SO-410 film was used with an exposure of 1/8 second at f/80. For additional photos showing the flare's development, see page 24 . Photograph by Leo C. Henzl Jr.


RETICLE
FOCUSING EYEPIECE
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A

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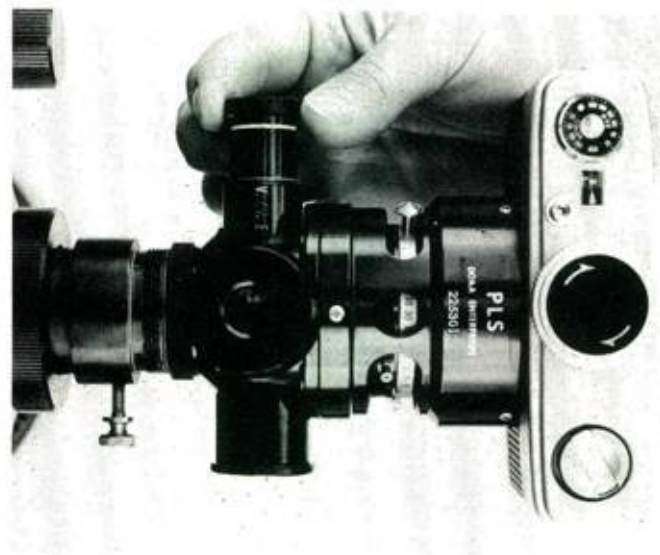

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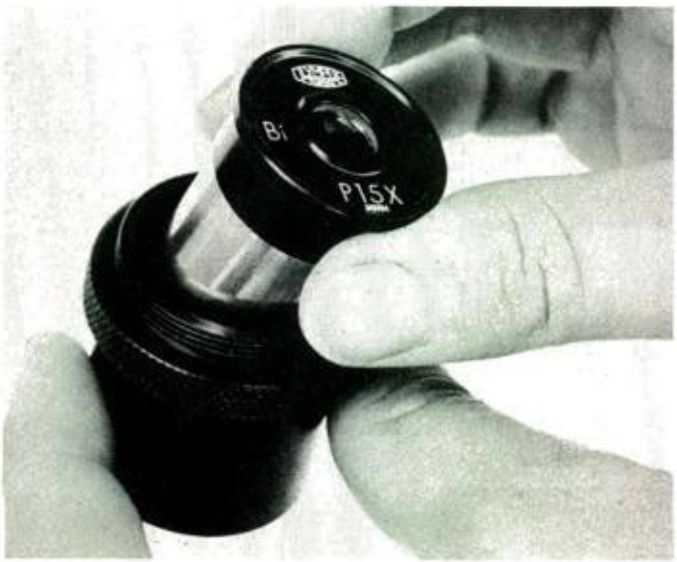

P15X

D

E

Jupiter displays its multicolored cloud belts and Red Spot in a three second exposure on High Speed Ektachrome. An eight inch Celestron telescope was employed along with a DOAA PLS camera. Photograph by Leo C. Henzl Jr.

Little Enterprises. Intended for scientific use like the PLS camera, the Laborec shares many of its features. Unlike the PLS, however, the Laborec is of familiar basic design — a 35mm SLR with moving mirror and focal plane shutter, not too different in general appearance from the Miranda SLRs marketed through photo retailers. But, as we'll see, the internal differences are many.

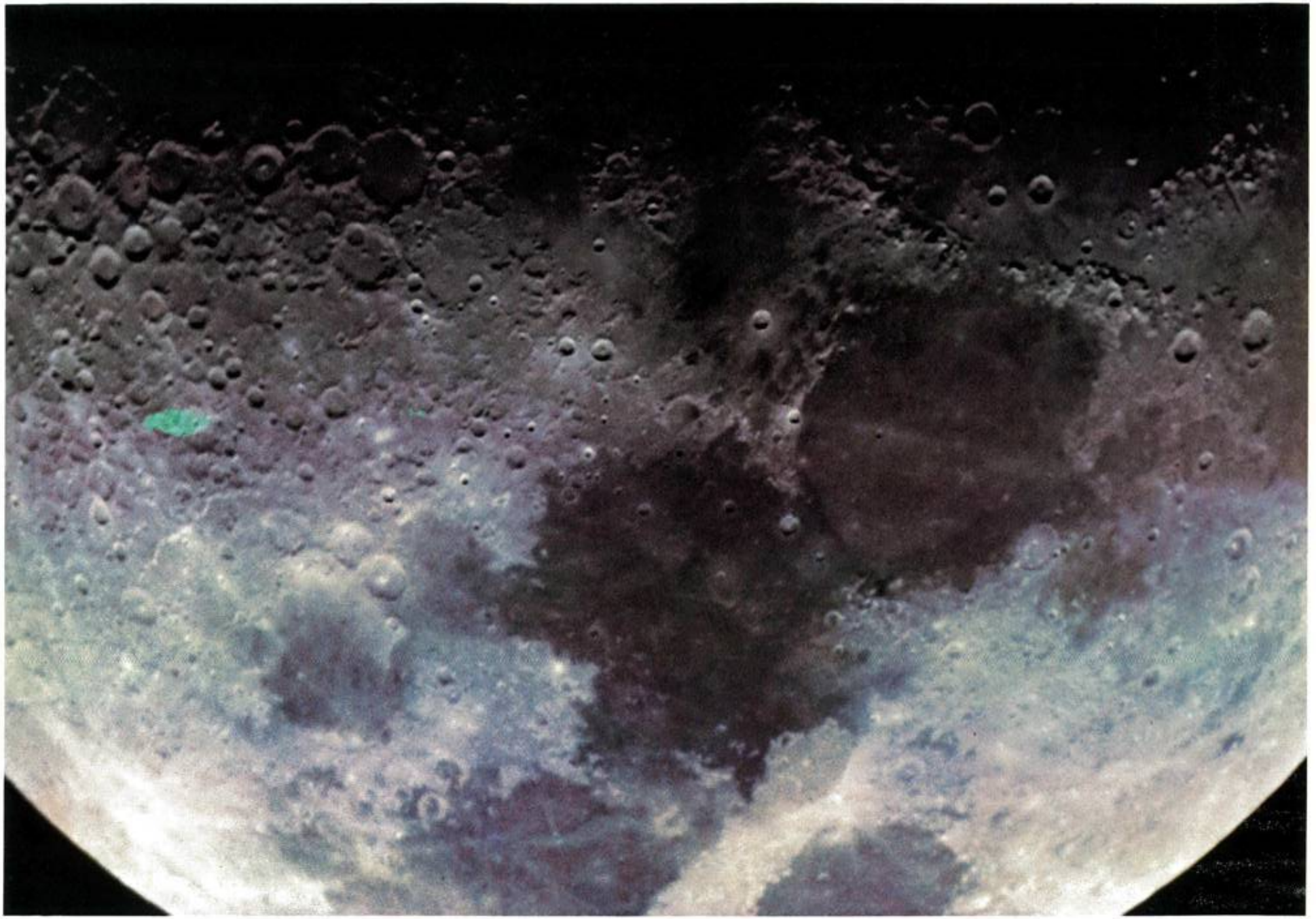
The Laborec lacks the PLS' ultimate sophistication and convenience in the specialized area of high resolution photography, but its more conventional design yields greater versatility. It is a true all-purpose astrocamera — well-suited to first-focus, afocal and piggyback applications, as well as positive-projection.

The first and most obvious difference between this camera and others bearing the Miranda label is the focusing system. Like other Mirandas, its focusing screen and viewfinder are user-interchangeable. But standard equipment with the Laborec is an aerial-image screen and right angle, diopter-correcting magnifier. Again, the focusing image is nearly as brilliant and detailed as a view through an ocular of comparable magnification, so there's no need to forgo the pleasure of a fine view of your subject in order to photograph it.

A common problem in framing a photo of the full solar or lunar disk through a telescope with a "garden variety" SLR is that — for reasons of economy or compact design — many manufacturers skimp slightly on the size of the quick return mirror. The result is darkening or image cut-off at the top of the viewing frame. This is not so with the greatly oversized mirror of the Laborec; the entire field is unvignetted with telescopes of any focal length.

Other SLR cameras afford the option of aerial-image focusing (at additional cost, of course), and the better ones generally incorporate mirrors of sufficient size. It is in actual astronomical use that the Laborec's photomicrographic pedigree becomes manifest. Resolution-robbing vibration in an SLR has two distinct causes: the focal plane shutter itself, and the quick return mirror — with the mirror usually the major culprit. Some name brand cameras solve this problem with a prelocking mirror, but this is generally a separate and time consuming operation. And while the mirror is prelocked, you have no idea of what antics may be occurring with atmosphere and drive. With the Laborec, though, shutter release and mirror prelock are integral functions. As you gradually depress the remote shutter relase, the Laborec's mirror slides gently up out of the way; the shutter will not trip until the mirror has fully cleared the film path. Thus, you view your subject without interruption until the moment of actual exposure — a great advantage over the procedure with standard SLRs. The shutter itself has uncommonly gentle recoil — on par, in this respect, with the most expensive name brand SLRs.

A) An inspection of the photo and diagram shows the PLS to be quite unlike any other camera available. Its beam splitter and shock-isolated shutter suit it uniquely to high resolution astrophotography. B) In position #1 of the beam splitter control (used for critical focusing), all incoming light goes to the focusing system as with conventional SLR cameras. C) But in position #2, the beam splitter sends only a portion of the light to the focusing system and the rest to the film. Result: The ability to monitor the image while the shutter is open. D) Special oculars, designed for positive projection use, drop into the nosepiece of the PLS — which in turn fits into a standard 1.25 inch I.D. ocular holder. E) Inexpensive colored filters, useful in lunar and planetary photography, screw into the front of the PLS. Such filters are available in a wide variety of colors and densities at modest cost.



A full aperture Solar Skreen filter on a home built four inch Cassegrainian telescope allowed this photo of the sun to be taken on Kodachrome X film at that moment of best seeing with the PLS camera. A 10 power eyepiece was used to increase the size of the sunspot cluster near the sun's limb. Photograph by Gerald Persha.

Advancing film in the Laborec also cocks its shutter, so that you must advance a full frame for each successive exposure. But, as we would expect in a camera designed for scientific applications, the film is advanced with a rotary knob. With a little care on your part, your subject should remain centered throughout an entire photo session.

The Laborec's lens mount is identical to that of other Miranda cameras, so it will accept a wide variety of Miranda-Soligor lenses for piggyback astrophotography. With inexpensive adapter rings, it also accepts Nikon, Exakta and Pentax (or similar screw-in) lenses — so it should prove attractive as a spare camera body to present owners of these cameras.

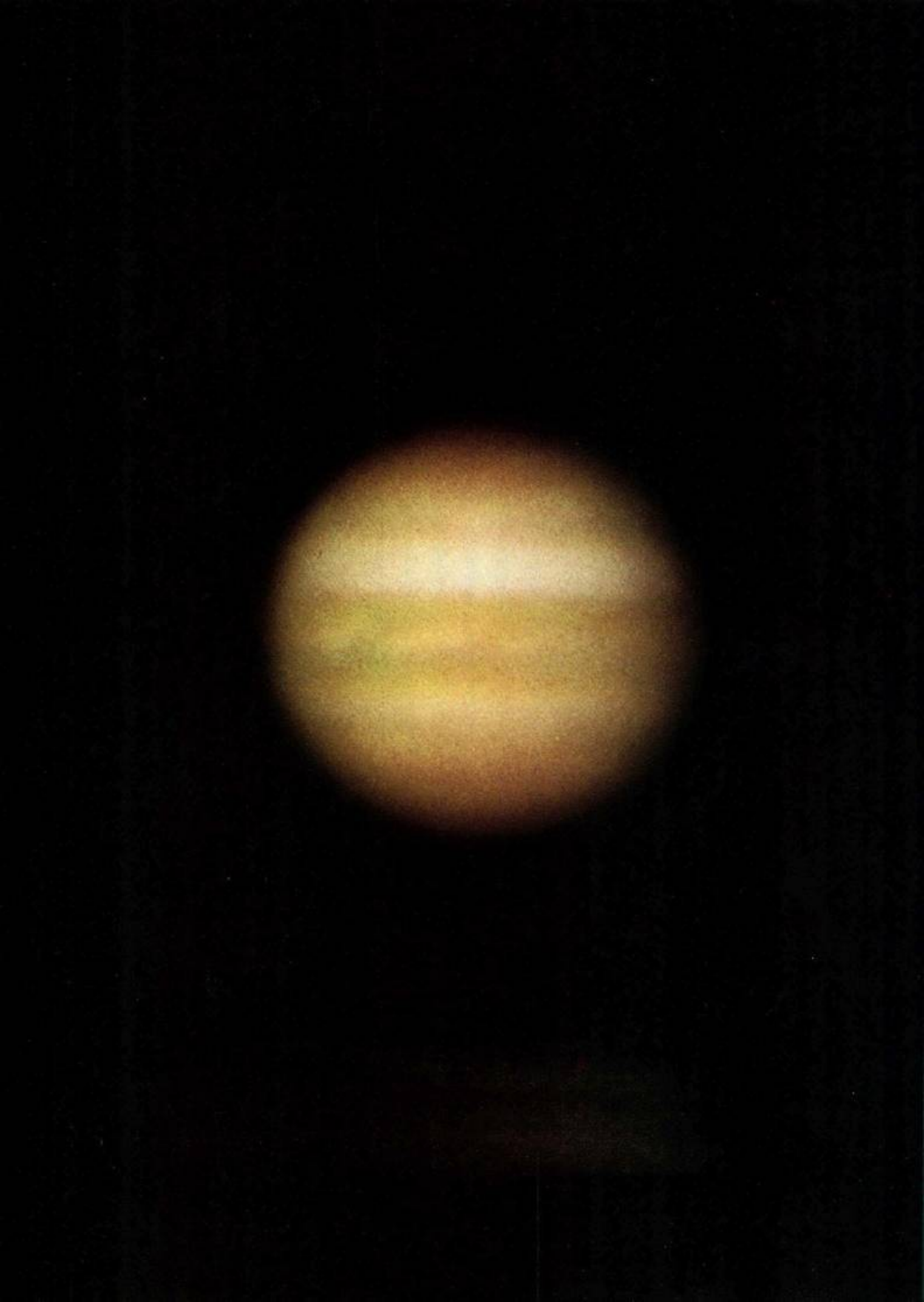
Although the Laborec's focusing system is ideal for use with long telescope effective focal lengths (EFLs), it is unsuitable for focusing camera lenses having normal EFLs. Its image with such lenses is as bright and crisp as that of a wide field finder telescope (a real asset in composing a constellation photo), but the point of exact focus is uncertain. This is inconsequential in piggyback photography where one simply sets his lens for infinity focus — but it does limit the Laborec's usefulness for types of photography other than celestial.

The Laborec also has a relatively limited range of shutter speeds — the top being 1/125 second — and it must be tripped via remote cable release as there are no provisions for hand holding. Thus, if your interest is in general photography, you'll probably consider the Laborec in terms of an extra camera body. If your interest is exclusively sky shooting, the Laborec may be as much camera as you'll ever need — and for $170, it's quite a bargain.

Although the Laborec isn't available through photo retail channels, it carries as a bonus the same three year parts and labor warranty that applies to other Mirandas, and can be serviced at any of several regional centers.

For more information on the Laborec, write R. T. Little Enterprises, P. O. Box E, Dept. LA, Brooklyn, N.Y. 11202.

This close-up of the first quarter lunar terminator was captured on Fujichrome R-100 in an AIC Laborec astrocamera mounted at the first focus of a Celestron 14 telescope. An exposure of 1/60 second was required at f/11 to record the fine detail on Earth's only natural satellite. Photograph by Leo C. Henzl Jr.



Observing Jovian Detail

by Lauray D. Yule

The first look at Jupiter through a telescope — whether a 1-1/2 inch refractor or any larger aperture — often brings a gasp of surprise. That brilliant point of light in the sky suddenly takes on shape — a tiny disk with form and color! It does not come to mind that this giant among the sun's nine planets has a family of 13 satellites — two of which are larger than the planet Mercury; that it takes a staggering 12 years to orbit its parent star; that its restless surface churns and changes as the giant spins on its axis in less than half the time Earth rotates; that this distant world — nearly 484 million miles from the sun — is more than two times as massive as all the other planets put together! Jupiter is a restless giant — a giant that despite a surface temperature (surface refers to the tops of the cloud layers) of -220 degrees Fahrenheit appears distinctly warm when viewed through a telescope of moderate aperture. (See "New Jovian Vistas", ASTRONOMY, November 1974.)

Jupiter reaches opposition on Oct. 11 and will offer excellent viewing over the next few months. It will be favorably placed in the sky, rising early in the evening by the end of October. Last year, Jupiter was poorly located in Aquarius and skimming the horizon. This year, in Pisces, it will be above the horizon haze and positioned nearly seven degrees above the ecliptic (an additional advantage for northern observers).

A Changing Surface

Jupiter's visible detail is astounding, and offers an additional attraction for the observer — continuous change. Features on Jupiter alter within a night's viewing of the great planet, and something new and unexpected is always happening.

This image of Jupiter, captured on High Speed Ektachrome with a five second exposure, was shot through a Celestron 16 telescope using a positive-projection system and a 35mm Olympus OM-1 camera at f/33. Dramatic color contrast in the belts and zones as well as distinctive limb darkening are shown in this November 1974 photo. Photograph by Norman Baier.

Jupiter, Saturn, Uranus and Neptune (the outer or Jovian planets) are remarkably different from the terrestrial or inner planets. They are not nearly as dense, as they are mainly gases (chiefly ammonia and methane). They are continuously enveloped in clouds, and it is doubtful if these worlds contain any extensive rocky cores. Jupiter, the largest and most easily observed giant, has cloud features so definite that there is no serious disagreement over the main details to be seen.

Belts and Zones

The basic color of Jupiter's disk is silvery-cream, darkening toward the limbs. Dramatic coloration becomes apparent in telescopic apertures of four inches or more, though subtle variations and shadings may be visible to the practiced eye with a 60mm refractor. Across the disk, dividing it into various zones, are several dark belts running parallel to the equator. These are visible in apertures of 1-1/2 inches, though the disk will appear gray rather than the creamy color seen in larger instruments. The dark belts often appear reddish-brown or orange in six inch and larger telescopes.

The belts — which form a framework for finer features — develop and fade from year to year. Usually the north and south equatorial belts are very conspicuous, as is the north temperate belt. The south temperate belt and high latitude features are somewhat fainter.

Jupiter's reluctance to become habit-ridden is one of its fascinations. Some of the belts often appear double, and larger telescopes show that the regions near the equator abound in complex detail — dark wisps, bright ovals, gaps — all examples of the tremendous turbulence that was suspected before, and proven by the Pioneer missions.

The Great Red Spot

One mysterious and obvious feature of Jupiter's surface is the gigantic storm known as the Great

THE GALILEAN SATELLITES				
Name	Mean Distance From Jupiter (miles)	Diameter (miles)	Orbital Period	Mean Magnitude
Io	262,000	2,000	$01^d18^h28^m$	5.5
Europa	417,000	1,750	$03^d13^h14^m$	6.1
Ganymede	666,000	3,000	$07^d03^h43^m$	5.1
Callisto	1,170,000	2,800	$16^d16^h32^m$	6.2

Red Spot (first noted in 1664 by English scientist Robert Hooke). Its color intensity changes; sometimes it is more brightly red than at other times. It may fade from view entirely for small aperture telescopes, and stay that way for decades. But the spot promises to be very bright this year — even better than last year. Telescopes of 60mm aperture will show this feature, whose internal structure was revealed by Pioneer 10 as a pinwheel-like vortex. Its rapid circulation pattern makes it rigid enough to displace the clouds of the south tropical zone, and sometimes it moves ahead or falls behind the rest of the cloud formations — gaining or losing an entire lap of rotation. The spot rises some five miles above the surrounding cloud deck, and the clouds at the top of the spot have less atmosphere above them and are cooler.

The Red Spot's internal structure is revealed by four to six inch telescopes at 200 to 300 power. The feature, under close observation, has dark, red-brown tips (horizontally) and a distinct red border. It also has a strange tail — seen even in small apertures — trailing to the right of the spot. The tail is the same color as the creamy bands found on Jupiter, and sometimes even appears to wrap itself around the Red Spot.

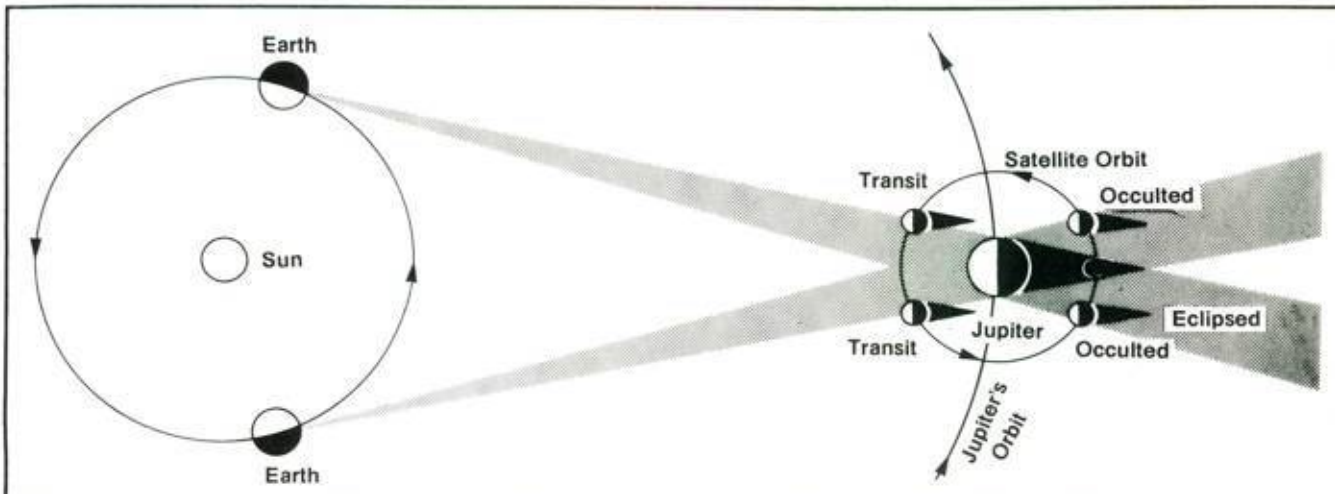
Disturbances visible ahead of the Red Spot are sometimes "caught" as the feature changes its orbital period, "swallowed up", and spiraled around within the spot before dissipating. This occurs over several days, but the progression of the phenomenon is well worth observing.

A dark colored strip that can only be described as a bridge has also been observed with larger (eight inch and above) apertures, cutting the spot in half vertically. Only practiced observers can see this feature, and it is also rarely observed — a fact well worth keeping in mind when viewing the spot closely as your observing skill increases.

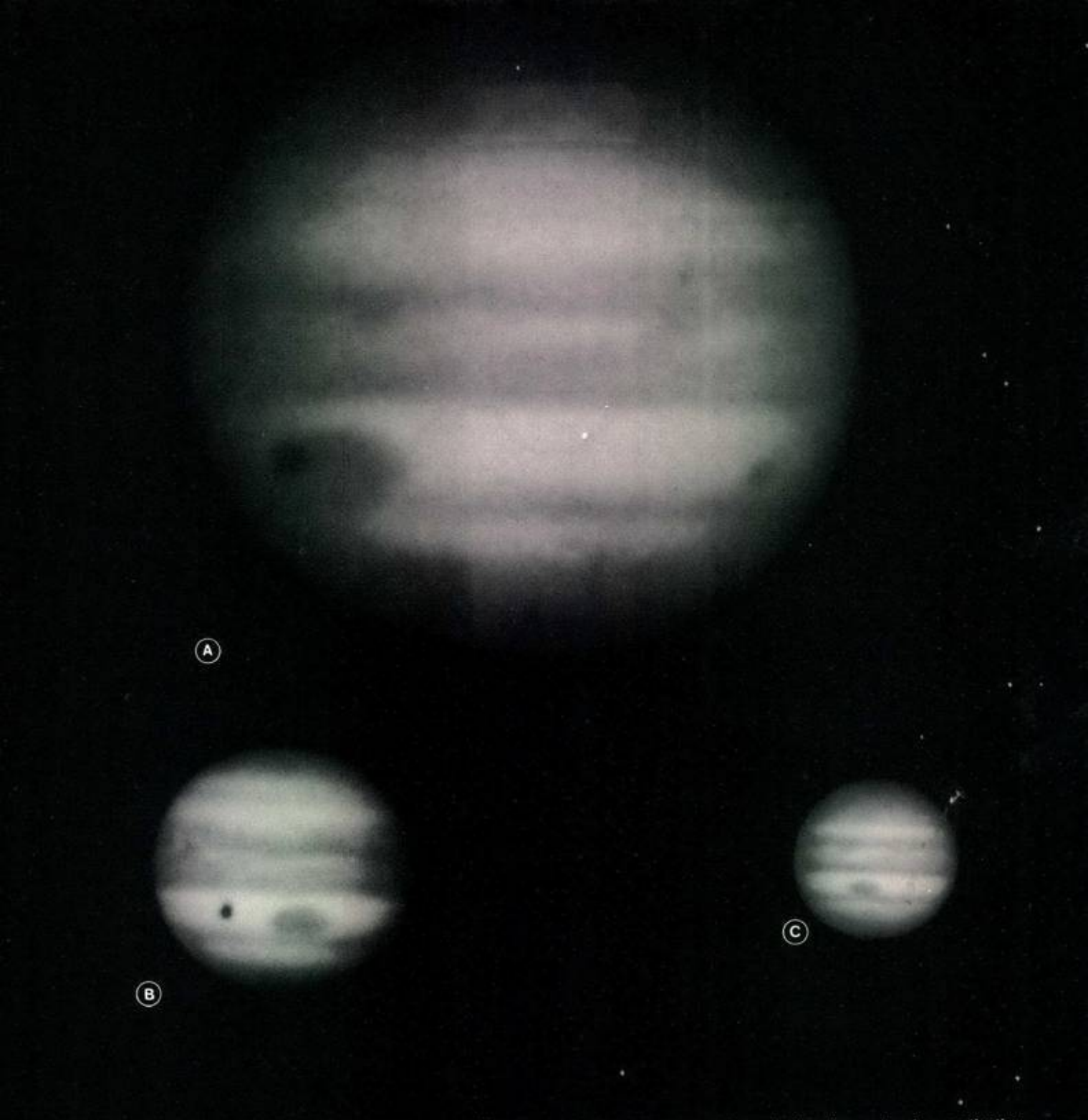
Another feature closely associated with the Red Spot is the Red Spot Hollow — a white oval sometimes ahead, behind or under the spot, but always nearby. Observing the position of the hollow is interesting, for at times the Great Red Spot seems to slip into the cavity, sticking only partly out of this depression. Again, speculation suggests a cloud formation into which the Red Spot sinks, but in any case, it is truly interesting observationally.

Rapid Rotation

Jupiter speeds around its axis in approximately 9 hours 55 minutes — the shortest day on any of the nine planets. This tremendous speed (22,000



The geometry of Jovian satellite eclipses and transits is shown here. When Earth is approaching Jupiter in its orbit, a satellite will first be eclipsed as it passes into Jupiter's shadow, and then occulted as it passes behind Jupiter. When Earth is going away from Jupiter, it will first be occulted, then eclipsed. Transits are shown occurring as seen from both Earth positions.



m.p.h.) causes it to bulge at the equator, resulting in an equatorial diameter of 88,729 miles and a polar diameter of 82,963 miles. But the tremendous speed varies slightly: The equatorial zone advances steadily relative to the rest of the globe. The regions north and south of the equator rotate about five minutes slower.

Features formed in Jupiter's atmospheric currents — though impermanent (lasting a few weeks or less) — have different rotational periods and provide valuable clues about the forces at work in Jupiter's atmosphere. By timing the rotation periods of these features, observers make their greatest contributions to the planet's study — as well as spending hours of enjoyable observing time. While recording *transits* (the time a particular feature

The giant among gas giants in the solar system is a captivating subject for photography as well as observing. Its satellites also offer excellent picture possibilities as seen in these photos. A) Ganymede's shadow and the Red Spot are captured together in this photograph of Jupiter, most dynamic of the planets. B) The shadow of Ganymede, largest of Jupiter's moons, transits the planet's disk, sharply superimposed on the southern equatorial belt. The famous Red Spot, the most dominant feature of Jupiter's cloud belts, has rotated beyond view. C) The Red Spot appears again in this image, transiting Jupiter's face in just under five hours. All three photos were captured with a Nikon F camera mounted on a home built eight inch f/7 Newtonian reflector utilizing 7mm eyepiece projection. Photos A and B were five second exposures on Kodak SO-410 film; photo C was a six second exposure on high contrast copy film to capture the dramatic detail in Jupiter's rapidly rotating belts and zones. Photographing planets requires excellent seeing conditions and considerable patience and skill. Photographs by James K. Rouse.

These sketches of Jupiter show the startling amount of detail available for viewing, and the tremendous, dynamic changes occurring literally hourly and nightly on the planet. The drawing on the far left was sketched from views through a 13 inch Fitz-Clark refractor at 195, 240 and 400 powers on the night of March 22, 1969. The close-up of the Red Spot, done on the same night, shows the strange phenomenon known as the bridge — a rare feature seen in the spot. Two nights earlier (center sketch), the planet features were totally different even though they were viewed through the same instrument under 195 and 240 power. On April 16, 1969, the face of Jupiter was amazingly changed again — proof that the largest member of the solar system is also the most dramatic to view. Artwork by Robert A. Schmidt.

crosses Jupiter's central meridian) may sound like a dull business, the enjoyment increases as skill and experience are gained.

Because Jupiter rotates so quickly, it is not difficult to time the instant at which a feature crosses its meridian. At first there may be an error of five minutes or so, but with experience a transit can be timed to the nearest minute. The longitude of the feature can be worked out from tables found in the 1975 **Observer's Handbook**. Different latitudes have their own rotation periods varying by several seconds from those nearby. Some 20 separate currents have been discovered, carrying along any features that happen to lie within them.

To determine transits, the observer draws an imaginary line in his mind north to south across the center of the planet's disk. When different features cross this imaginary line determines meridian transits.

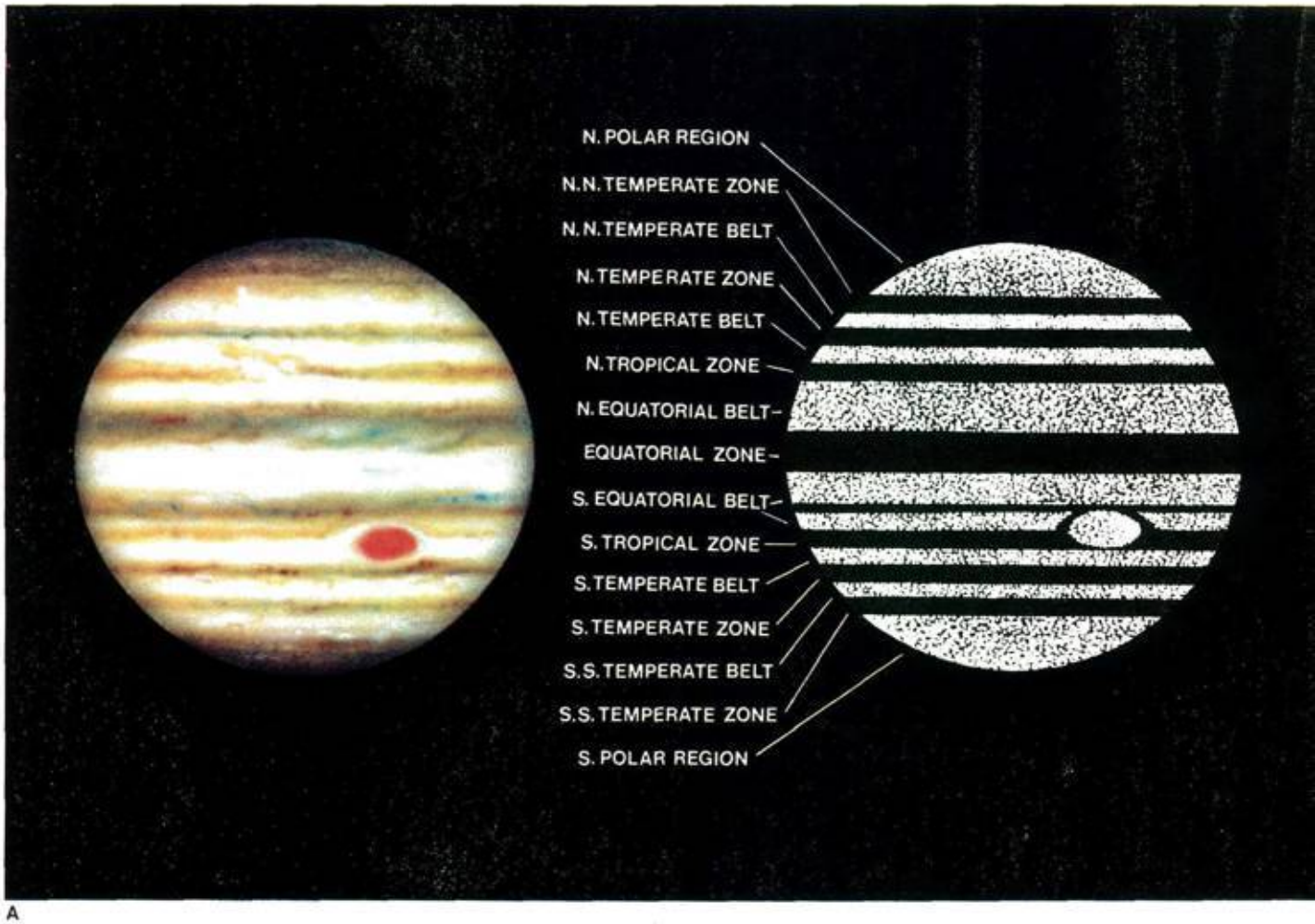
The Red Spot is a good beginning subject for transit recorders because a 60mm refractor at 100 to 150 power clearly reveals this prominent feature. It transits Jupiter's face in approximately 4 hours 57 minutes. Jupiter's rotational period is 9 hours 55 minutes. Therefore, by determining when the Red Spot reaches the center of the planet's disk and noting that time on your watch, it is possible to predict where the Red Spot will be at any given time. If Jupiter rotates twice between observing periods, simply add 19 hours 50 minutes to the time you noted transit before. The spot should be fairly close to its original position, though it does vary in rotation period slightly. This knowledge is also valuable for observing sessions — especially when introducing new observers to Jupiter's features. The Red Spot is so distinct that even the beginner can enjoy it and soon graduate to more subtle detail.

The spot can be used for a further transit observing project as well. Note the times the feature's leading edge (the left one), the center and then the trailing edge cross the meridian. By adding together the total time from leading to trailing edge and dividing by two, the transit time of the spot's central area can be determined. The times can vary between a minute or two, but the more practiced your eye becomes, the greater the accuracy and challenge.

Much of the knowledge concerning the behavior of Jovian features and currents resulted from observations by nonprofessional astronomers. Organizations have been developed specifically to accept data from observers with small telescopes to further study Jupiter's changing surface — although today, professional planetary patrol stations and space probes are photographing fine detail beyond the reach of small telescopes. Astronomy enthusiasts may be rewarded with a Jovian first, however — the discovery of a new storm system perhaps. Odds are in your favor that few professional telescopes will be turned toward the giant on a given night, making the challenge to observe Jupiter even more exciting.

Jupiter does not have a sharp limb as the other planets do. Its illumination falls off by a factor of 40 percent at the edge of the disk, which is the easiest part of a planet on which to properly focus. As a result, medium powers work with no disadvantage since the disk is so large. Good views can be obtained with 75 power on a 2.4 inch refractor or 190 power on a six inch reflector. A 60mm refractor will show detail, but larger apertures naturally reveal more

Jupiter's varying faces are shown in these photographs. The Red Spot appears in two of the images. A satellite shadow transit is visible in one of these. Still another view of the planet reveals its dramatic cloud belts, showing some of the white patchlike disturbances also characteristic of Jupiter. Lick Observatory and Lunar and Planetary Laboratory photographs.



A

(A)
A stylized representation of Jupiter (left) is compared with a diagram showing the various regions designated on the planet's surface. The swirling belts and zones, alive with color and constant change, can be viewed even through small aperture instruments on nights of fine seeing. The Red Spot, a gigantic disturbance in the south equatorial belt and tropical zone, is an obvious and arresting feature in apertures of 2.4 inches and larger. Artwork by Victor Costanzo.

(B)
The Great Red Spot dominates this photograph of Jupiter, showing some of the swirling surface features characteristic of the largest of the gas giants beyond the asteroid belt. U.S. Naval Observatory photograph.

(C)
A five second exposure of Jupiter on High Speed Ektachrome reveals much detail about this active planet. The Red Spot is startlingly apparent on the right hand side of Jupiter approaching the terminator. The photo was shot utilizing 7mm eyepiece projection on a home built eight inch f/7 Newtonian telescope; a Nikon F camera was used. Photograph by James K. Rouse.

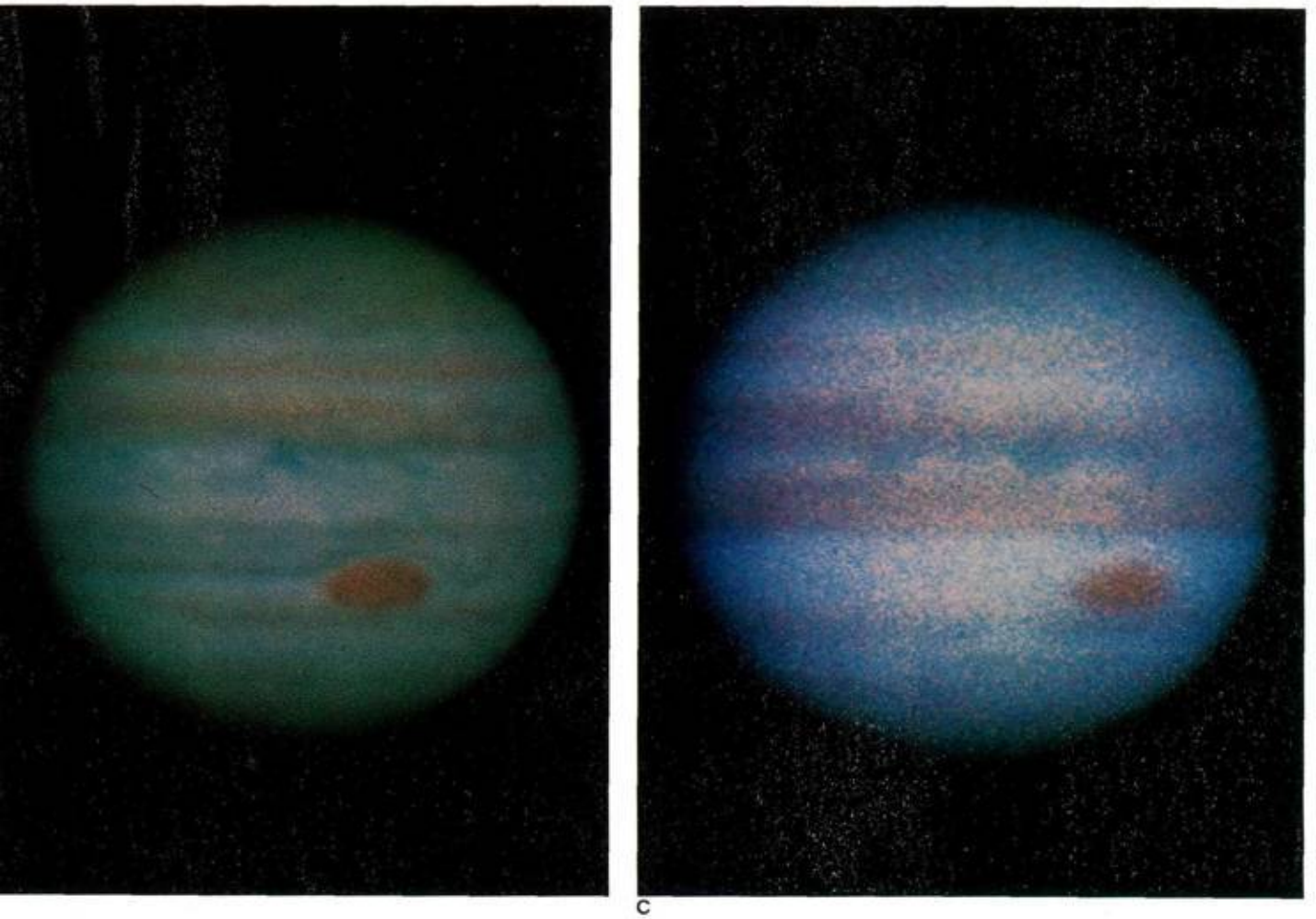
delicate features. Colors and detail are extremely striking through 12 inch or larger apertures.

The Galilean Satellites

Even a pair of 10 power binoculars will reveal Jupiter's disk and the four brightest satellites discovered by Galileo. Though the other nine in Jupiter's family of 13 moons are too faint for small telescopes, some sharp eyed observers claim the four brightest moons are visible to the unaided eye. For most viewers, however, the bright glare of the planet masks the Galilean satellites from naked eye visibility. Watching the four satellites as they orbit in nearly exactly the plane of Jupiter's equator can absorb an entire observing session. Each is as individual as the mythological characters after whom they are named. Their nightly positions as they would look in a telescope are listed in Sky Almanac; with a little practice it is easy to tell them apart. Io moves the fastest and is never very far away from Jupiter. Europa has a rather dull, grayish tint. Ganymede is easily seen because of its brilliance, and Callisto is the slowest moving and faintest of the four. It is worth keeping an eye on the satellites' relative magnitudes. Callisto has sometimes been recorded as having nearly the same brightness as Ganymede, and Io also shows fluctuations.

A low power eyepiece gives a fantastic view of the four moons. Their positions change perceptibly from hour to hour as they course around Jupiter. The mammoth size of the planet is easier to comprehend when the observer realizes Ganymede is slightly larger than the planet Mercury.

Even a six inch reflector will reveal Ganymede's disk to a relatively inexperienced observer, and experienced observers with four inch instruments and adequate magnification can also be rewarded with a disk on nights of fine seeing. Surface detail



C

can be seen only in large aperture telescopes — usually refractors — though some reports claim a 12 inch aperture is sufficient to see detail on nights of good seeing. The other satellite disks can be seen at higher magnifications with apertures of six inches or more on nights of good seeing.

Jupiter's moons are often eclipsed — far more frequently than our moon, because Jupiter's shadow (compared to Earth's) is much larger. At other times they pass in front of (or transit) Jupiter's disk.

Observing satellite shadows on Jupiter compounds viewing pleasure and offers additional challenge to the astronomy enthusiast. These are called *shadow transits* and are equivalent to what a Jovian observer would see on Earth's surface when we experience a solar eclipse. At the eyepiece, satellite shadows look like sharply defined black dots on Jupiter's surface. On nights of good seeing, shadow transits can been seen with a 2.4 inch refractor at 100 to 150 power. Actual satellite transits (the passage of a brighter moon across the darker belts and detail of Jupiter) require a six inch telescope. Ganymede is a particularly good subject for this kind of observation because it is large (thereby casting a large shadow on Jupiter) and very bright (making it easier to view against Jupiter's almost equally bright surface).

Shadow transits of Jupiter's central meridian can be an enjoyable observing project. (Again, a 2.4 inch refractor at 100 to 150 power is suitable for timing the shadow as it travels across the planet's face.) Note shadow *ingress* (when it first touches the disk), when it crosses the central meridian, and *egress* (when it leaves Jupiter's disk). Take the difference between egress and ingress and divide by two. This should give you the meridian transit time. As you become more skilled, compare your results with those listed in the 1975 editions of **American Ephemeris and Nautical Almanac**, or the **Observer's Handbook**.

A rare phenomenon sometimes occurs near the limbs of Jupiter during shadow transits. The shadow appears to split in two, remain that way for several minutes, and then reunite. Theory speculates this optical illusion is caused by atmospheric disturbances on Jupiter — but in any case, the astronomy enthusiast can enjoy such rare events with persistent observing.

Jupiter offers a sharp contrast to the terrestrial planets. Their small static disks hardly compare to Jupiter's large, luminous and dynamic image. The Galilean satellites are an added bonus which the rest of the giant worlds do not offer to small aperture telescopes. Giant Jupiter continuously offers new impressions and phenomena for observation.

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Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. The following back issues are depleted: September, October, November, December 1973; January, February, May, August, October, December 1974; March and April 1975.

Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly, and completely revised about every six months. While they last, back issues are available for the cover price of $1.50 each (price includes postage).

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

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Vol. 2, No. 4 - April 1974	Short Supply	Vol. 3, No. 9 - September 1975	Available
Vol. 2, No. 5 - May 1974	Short Supply	Vol. 3, No. 10 - October 1975	*NYP
Vol. 2, No. 6 - June 1974	Short Supply	Vol. 3, No. 11 - November 1975	*NYP
Vol. 2, No. 7 - July 1974	Available	Vol. 3, No. 12 - December 1975	*NYP
Vol. 2, No. 9 - September 1974	Available	Vol. 4, No. 1 - January 1976	*NYP
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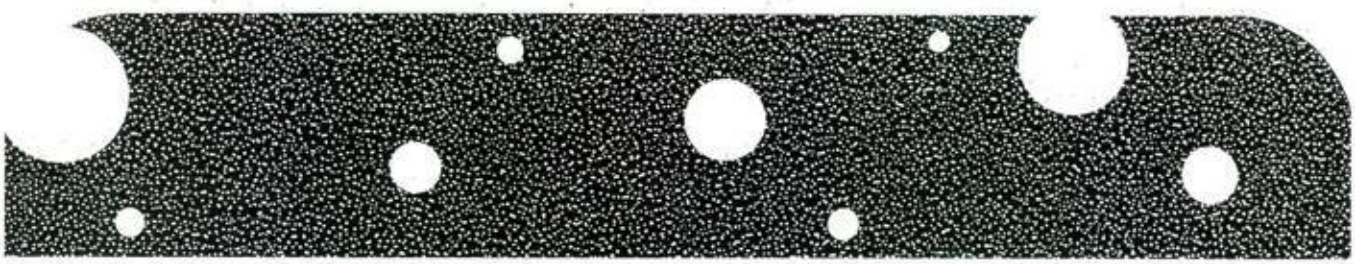


Shape of the Milky Way

by
Gerrit L. Verschuur

And with an awful, dreadful list
Towards other galaxies unknown
Ponderously turns the Milky Way....

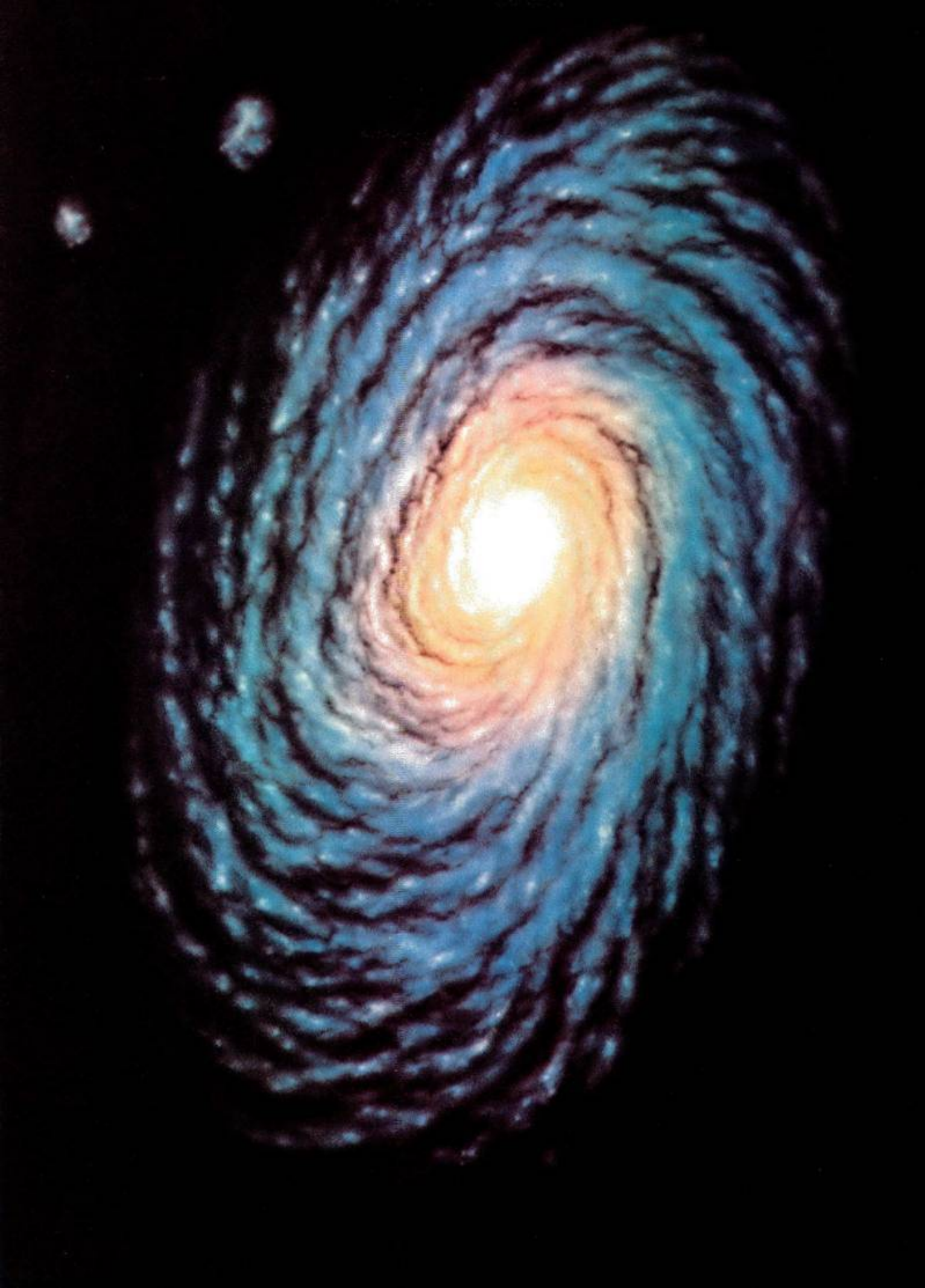
This insight by Pasternak portrays some of the splendor inherent in our Milky Way galaxy as it slowly rotates once every 300 million years. Traditional views depict the Milky Way as a flat disk about 600 light-years thick and 100,000 light-years across, with the sun lying about 30,000 light-years from the center. However, a detailed view of the size and shape of our galaxy is difficult to obtain since we are located inside it.

Observing distant galaxies reveals most have a fairly well-defined spiral structure. Main star and dust concentrations follow a spiral pattern outward from galaxy centers. Our Milky Way should also have such spiral features. Unfortunately, we see very few stars inside our parent galaxy. Interstellar dust restricts seeing anything but the nearest stars and nebulae; beyond 5,000 to 10,000 light-years from the sun, we see relatively little of the Milky Way. We are also blocked in the direction of the center by enormous numbers of stars in the constellation Sagittarius, so methods we use to infer the Milky Way structure are indirect.

Original estimates of the Milky Way's size and shape were based on distances to globular clusters. These old groupings of stars occupy a spherical region of space centered on what we now know is the Milky Way core, about 30,000 light-years away. Thickness estimates of the galactic disk are made by studying how numbers of stars decrease with distance from the central lane of the Milky Way.

Optical data on distances to young star clusters and individual stars within 10,000 light-years provides a sketch of our solar neighborhood. It appears the sun does not occupy a spiral arm, but rather a spurlike projection (called the Orion spur) from one of the arms that runs near us. In the direction of Perseus we see many young stars and star groups — such as the famous double cluster in Perseus — all forming part of another spiral feature called the Perseus arm, about 10,000 light-years away. Toward the constellation Cygnus we find a very large number

From intergalactic space, our Milky Way galaxy appears as a majestic pinwheel of more than 250 billion stars. Its most prominent feature is the bulbous galactic nucleus, a sphere where most of our galaxy's older stars are concentrated. Lanes of stars interlaced with clouds of dust and gas spiral outward, filling a 100,000 light-year diameter disk — with our sun lying roughly 2/3 the distance from the galaxy's nucleus to its edge. Two small satellite galaxies, the Magellanic Clouds, are seen nearby. Artwork by Victor Costanzo.



of young stars, gas and dust along a spiral arm section called the Cygnus arm, and toward the galactic center we find another spiral arm sweeping from the region of Sagittarius to Carina. These three major features are the only ones clearly distinguishable optically.

The most recent attempts to formulate a picture of the Milky Way's appearance come from studying radio emissions by interstellar hydrogen gas clouds. The basic hydrogen atom consists of a proton at its center with an electron orbiting about it. Both particles also spin about their own axes, much in the way Earth spins on its axis while orbiting the sun (which in turn spins on its axis). In space, the electron and proton randomly change their spin directions. When such a spin-flip occurs, the atom's energy changes. Under suitable conditions found in interstellar hydrogen clouds, atoms radiate a radio signal as a result of this spin-flip. Hydrogen clouds can only be observed this way — their radio signals having wavelengths near 21cm. Radio emissions from interstellar hydrogen gas were discovered in 1951; since then many astronomers have been studying interstellar hydrogen's temperature, density and size, and learning about the distance to the hydrogen clouds. Based on these distance measurements, astronomers can draw a picture of what the Milky Way really looks like.

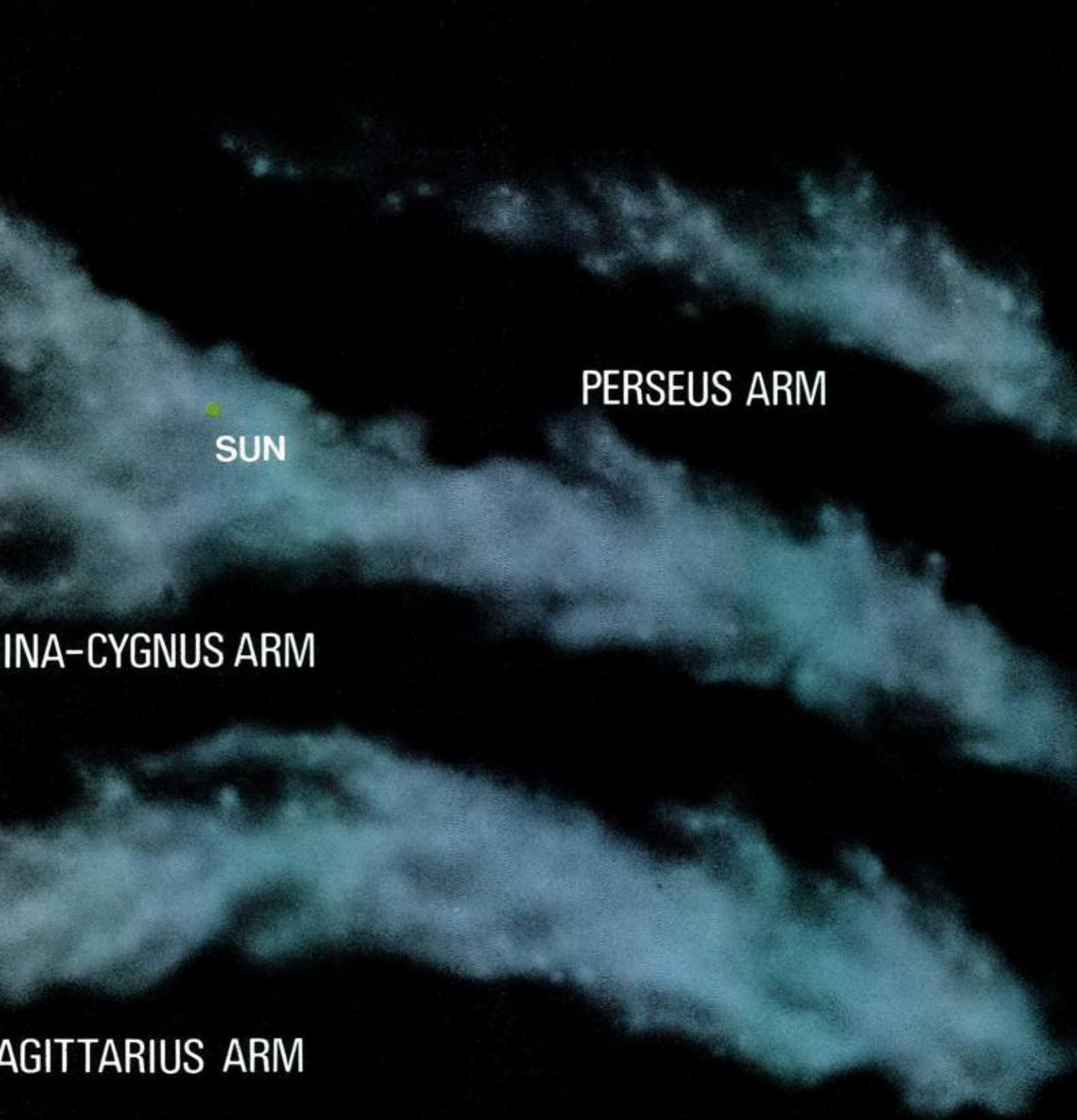
This process is far from perfect since astronomers must make several important assumptions before deciding where the hydrogen is located. Basically, the distance to an observed cloud can be estimated by measuring how fast it is coming toward us or moving away from us. Once that is done, and if we know how the Milky Way is rotating, we can then calculate distance to the hydrogen cloud responsible for the observed signals.

The sun and neighboring stars are moving at about 150 miles per second around the galactic center. We cannot easily become aware of our motion around the Milky Way hub, just as someone sitting on the rim and spokes of a wheel would be unaware of motion if he looked at only the rim and spokes of the wheel. But if he looked out at the distant pavement, he would discover that he was moving around in circles. Likewise, we could look at distant galaxies to infer our motion except that we can hardly wait for 300 million years to elapse (the time it takes to make one revolution) before confirming we are moving in circles. Astronomers assume we move about the galactic center because observations of distant galaxies suggest circular motion is a common situation.

Assuming circular motion and observing the motion of hydrogen, we can estimate the distance to hydrogen gas almost anywhere in our galaxy. Hydrogen seems to be structured in strings or ribbons of matter spreading out over large distances, just as spiral arm structure should look.

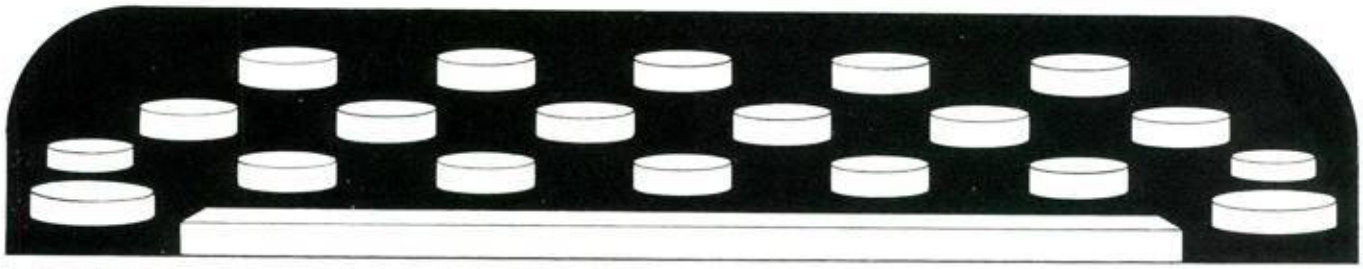
Our sun occupies a spurlike collection of stars attached to one of the Milky Way's spiral arms. Looking toward the galactic center in the direction of Sagittarius, astronomers find a neighboring spiral arm made up of many young stars, gas and dust. Another bordering spiral structure lies in the direction of Perseus. These features are all we can optically see of the Milky Way galaxy. Artwork by Victor Costanzo.

Recently it was discovered in the northern sky that many hydrogen clouds are apparently traveling toward us at speeds up to 125 miles per second. In the southern skies there appear to be similar high velocity clouds moving away from us. Their



presence cannot be explained if we believe the galaxy is a flattened rotating disk. The cloud behavior implies our galaxy's outer regions are highly distorted. This distortion is probably due to interaction between the Milky Way and the Magellanic Clouds. These small neighboring galaxies appear to have passed by our galaxy hundreds of millions of years ago, much as a comet passes by the sun. Recent evidence has been found for a bridge of matter between the Magellanic Clouds hundreds of thousands of light-years long (see ASTRONOMY, January 1974). In addition, there may be a countertail stretching way beyond our galaxy, in the opposite direction of the Magellanic Clouds. This countertail lies in the constellation Taurus.

New observations by radio astronomers in Australia suggest galaxies do not wander about as isolated entities as was previously thought. There may be long hydrogen gas streamers crisscrossing intergalactic space and linking galaxies. It is difficult to distinguish whether such clouds are really the outer parts of one galaxy (a distant spiral arm section) or whether they are intergalactic hydrogen. Today it is clear that based on the study of radio emission from hydrogen gas, we are not living in an ordered, flat disk galaxy.



Sir / I greatly enjoy your magazine and find it both beautiful and informative. I have noted with some interest, however, that the amateur astrophotographs appearing in your magazine have all apparently been taken by men. Surely there are some women astronomy enthusiasts who have taken quality astrophotographs worthy of publication in your magazine. I realize that this is a minor point, but please encourage female participation as there are some of us out here who would enjoy seeing work by other female astrophotographers.

I do plan to do my part! I found the four day old moon especially beautiful on the night of July 11, and enclose a slide you may wish to publish.

SHARON HOVELN
St. Joseph, Ill.

Ms. Hoveln / When you consider that only 7-1/2 percent of ASTRONOMY's readership are women — a considerably lower percentage of which are photography enthusiasts — it becomes downright difficult — no, impossible! — to find sky photos in our mail made by women. Since your moon photo was quite good, we decided to reproduce it in Sky Almanac on page 22 of this issue. How's that for encouragement? And if you can do that well at astrophotography, how about more photos?

Sir / In "Showers of Fire" (August 1975) you spoke briefly of telescopic meteors. When I first read that, I thought it was absurd; the chances of a meteor crossing the field of a telescope must be astronomical. I thought no more about it.

About midnight on August 13, I was looking at Zeta Lyrae with my 4.25 inch reflector when—you guessed it—a Perseid flashed by. It was relatively bright — about magnitude -1. The trail was a little less than a minute of arc wide; it remained for three or four seconds, then began to fade out. The center of the trail became grainier and disappeared. Meanwhile the graininess spread to the edges and disappeared in about a second.

I apologize for having even a moment's doubt about your superb magazine.

JEFF YANTIS
Seattle, Wash.

EDITOR'S NOTE: The photograph on ASTRONOMY's August 1975 cover was incorrectly attributed to Leo C. Henzl Jr. The photo was taken by Hans Vehrenberg.

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ASTRO-MART

continued from page 49

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WANTED — Olympus OM-1, with or without 50mm f/1.4 lens. Should be in used (up to 1 year old) but fine condition. Please state price. Write Dave Eschhofen, 925 N. Tyndall Ave., Apt. 103, Tucson, AZ 85719.

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WANTED — October 1973 issue of ASTRONOMY. Must be in good condition. Please state price. Write David Yoh, 19 Meadow-Lark Dr., Walhalla, SC 29691.

WANTED — Back issues of ASTRONOMY: October, November, December 1973; January, August 1974. Must be intact and in excellent condition. Will pay $16.00 for the 5 issues. Write Morton Liberman, 2815 Ocean Pkwy., Apt. 4-K, Brooklyn, NY 11235.

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WANTED — Members for Operation Skywatch (registered in Washington, D.C. and recognized by NASA). Purpose to explore the mysteries of the universe. For further information, write John V. Rella, c/o Operation Skywatch, 23 Falmouth Rd., Yonkers, NY 10710.

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WANTED — October 1973 issue of ASTRONOMY. Must be in new condition; will pay up to $10.00. Send address and condition ONLY to David L. Womack, 1108 Donaldson, San Antonio, TX 78228.

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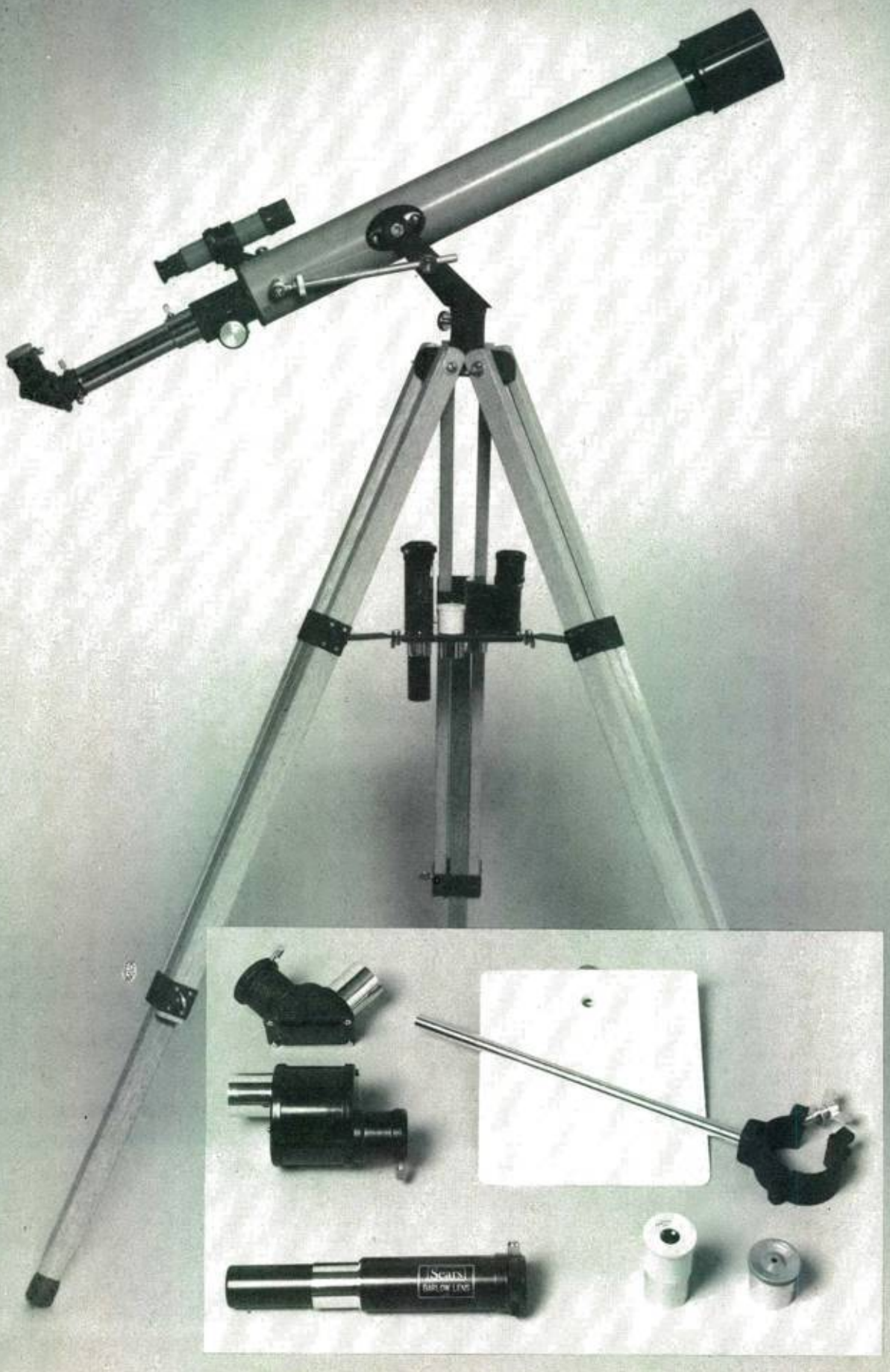
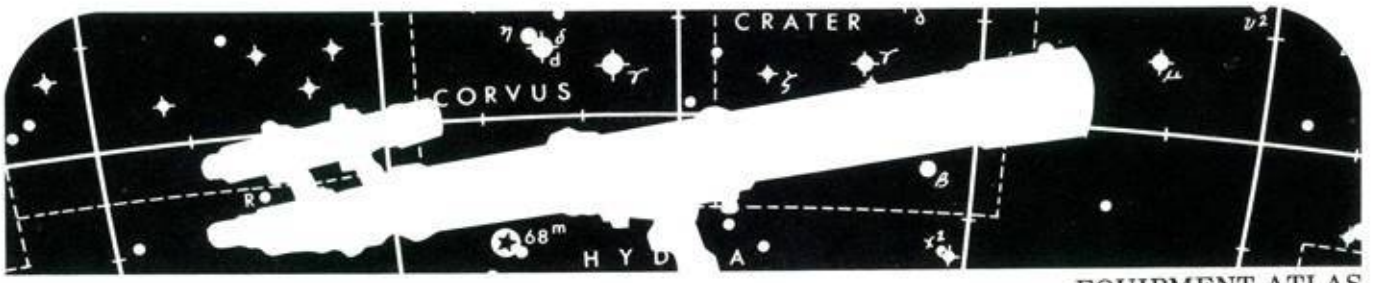

Sears
Roebuck Line



EQUIPMENT ATLAS

Buyers' Guide to Telescopes

by
Thomas Cave and James Mullaney

The 2.4 inch (60mm) refractor telescope on the opposite page is typical of the department store variety. This Sears model #4426 altazimuth refractor retails for $82.99 and sports a modest — though varied — assortment of features and accessories a budding young astronomy enthusiast might want or need to start exploring the night sky. An adjustable wooden tripod allows comfortable viewing from a standing or sitting position, and a convenient tray suspended between the tripod legs places accessories within easy reach. The telescope's objective lens — a coated, air spaced achromat — has a short focal length for a refractor (700mm), which gives the erroneous impression that the instrument is "smaller" than it should be. Accessories for Sears model #4426 (see photo insert, lower R) include a star diagonal, erecting prism, two power coated Barlow lens, sun projection screen and two eyepieces — an achromatic 20mm focal length Kellner and a 6mm Huyghenian.

The selection of a good telescope is perhaps the most important, complex and rewarding decision you will ever have to make as an astronomy enthusiast. While the wonder and beauty of the night sky can be enjoyed with the unaided eye and binoculars, true exploration of the heavens requires an astronomical telescope — one that is optically and mechanically sound, reasonably priced and sufficient for the needs of the active observer. With the right choice, such an instrument can provide a lifetime of use and pleasure.

Since the Christmas gift buying season is swiftly

REFRACTOR TELESCOPE SUPPLIERS & DEALERS

Name	Where Available	Write for Catalog	Delivery	60A*	60E*	3"E*	4"E*
Colonial Optical Co., Inc. (Mayflower) 8401 S.LaCienega Blvd., Dept. AM-10 Englewood, CA 90301	mail orders only	free catalog	mail & UPS	$120 to $190	$300	$440	—
Consumer Service Jason/Empire, Inc., 9200 Cody, Dept. AM-10 Overland Park, KS 66214	Woolco Treasury Treasure Island Fortunoff's	write for information on dealer nearest you	shelf item	$75 to $195	$210 to $600	$450 to $600	—
Edmund Scientific Co., 300 Edscorp Bldg., Dept. AM-10 101 E. Gloucester Pike, Barrington, NJ 04007	mail orders only	free catalog	week to 10 days; don't order after Thanksgiving for Christmas delivery	$115	$275 to $550	$200	$420
Meade Instruments, 721 W. 16th St., Dept. AM-10, Costa Mesa, CA 92627	mail orders only	catalog: $1	2 weeks	$165	$177	$325 to $375	—
Sears & Roebuck	all local stores	—	shelf item	$75 to $99	$175	—	—
Swift Instrument Corp., P.O. Box 562, Dept.AM-10 San Jose, CA 95106	Abercrombie & Fitch	free brochures will sell via mail if there is no dealer in your area	shelf item	$120 to $240	$180 to $369	—	—
Tasco Sales Inc. P.O.Box 380878, Dept. AM-10 Miami, FL 33138	Payless Drugs Alden Catalog (Gamble-Skogmo) Macy's	free catalog, you may purchase direct if there is no dealer.	shelf item	$150 to $300	$300 to $600	$700 to $775	$2,500
Unitron Scientific, Inc., 66 Needham Street, Dept. AM-10 Newton Highlands, MA 02161	mail order only	free catalog	2 to 6 months	$189	$370 to $469	$614 to $1,020	$1,255 to $1,779

* A - Altazimuth Mount E - Equatorial Mount

approaching, we present here for your convenience a simplified guide to telescope buying based on tried and proven instruments and manufacturers. Our discussion will be confined to the sizes of practical interest to most enthusiasts. Approximate current prices are given for each type of instrument — as well as size and make — together with other useful information that should help in selecting a particular model. Aperture range is between 60mm (the common 2.4 inch refractor) and eight inches.

As far as visual observation is concerned, there are three basic types of telescope — the *refractor* (lens type), the *reflector* (mirror type) and the *catadioptric* (compound lens/mirror system). Historically the first two telescope designs are the oldest. Both were invented in the 1600s but were not perfected to their present state of excellence until much later. Catadioptric systems have been with us for only a matter of decades.

Refractors

Although the design of the refracting telescope has been with us for nearly four centuries, its simplicity makes it a fine choice for the beginning astronomy enthusiast today.

It has just one main optical element — the *objective lens* — permanently mounted and aligned in one end of the telescope tube. With the eyepiece inserted at the opposite end, the tube is completely closed so it remains dust and moisture free. The only maintenance required in normal use is periodic cleaning of the objective's external surface; with a little care, it will last a lifetime.

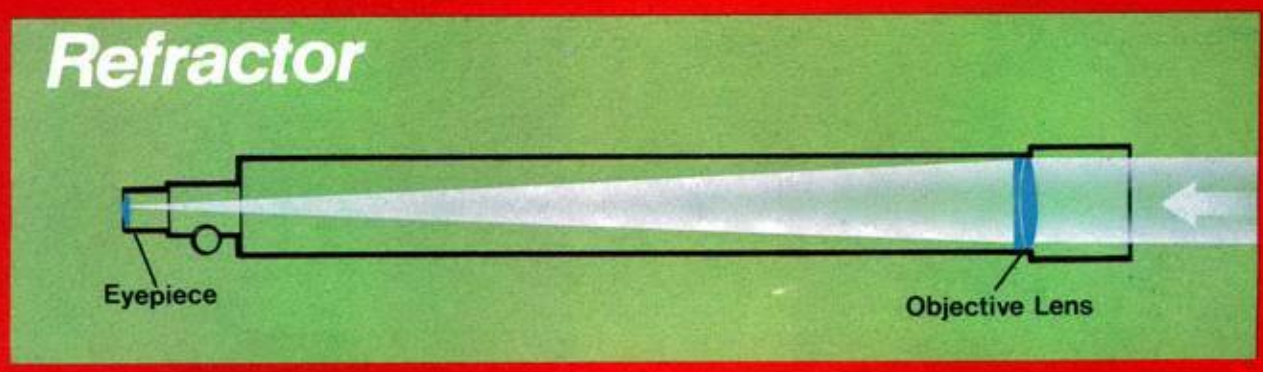
Newspaper ads for small refracting telescopes often emphasize maximum power or magnification. These claims should be ignored for the most part; it is the telescope's aperture that's really important. No telescope — whatever its design — can deliver good performance with more than 90 or 100 power per inch of aperture, and only then under superb seeing conditions. Normally, magnifications of 50 or 60 power per inch are more acceptable. On nights of bad seeing, higher magnifications merely magnify the bad seeing. All things being equal (instrument quality and seeing conditions), a larger aperture telescope will always outperform one of lesser aperture.

Refractor apertures range in size from less than one inch to the 40 inch Yerkes Observatory lens. But in comparison to other telescope types, refractors are relatively expensive per inch of aperture, as well as bulky. If you desire a telescope with an aperture greater than four inches, your best bet would be a reflector or catadioptric instrument.

REFRACTOR COMPARISONS

Aperture	Magnitude Limit	Resolving Power (seconds of arc)	Highest Magnification
60mm (2.4")	10.7	1.9	228X
76mm (3")	11.4	1.5	289X
80mm (3.1")	11.6	1.4	304X
102mm (4")	12	1.1	388X

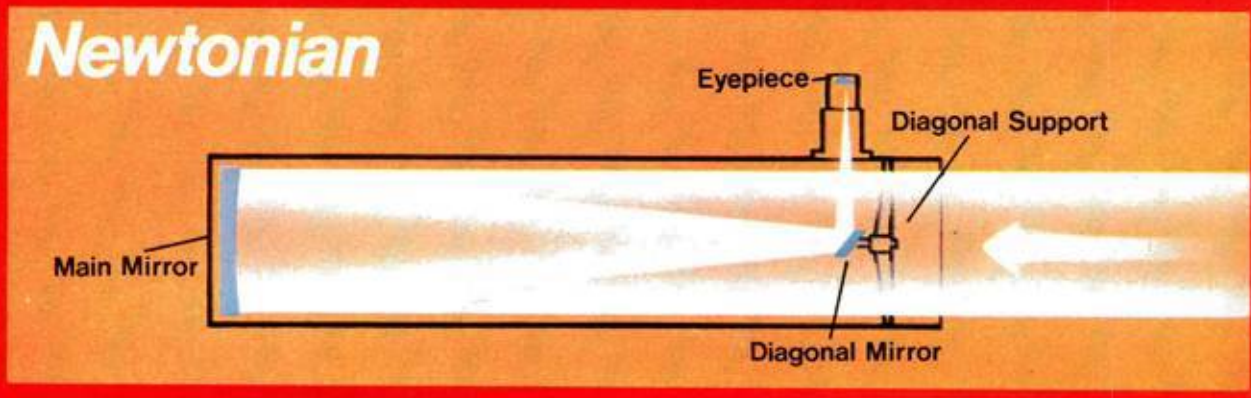
These maximums are theoretical limits only. Optical quality, atmospheric seeing conditions, observer training, and physiological differences among observers' eyes may reduce or expand the limits.



NEWTONIAN REFLECTING TELESCOPE MANUFACTURERS

Supplier	Catalog	Delivery*	4-1/4"	4"	6"	8"
Cave Optical Co. 4137 E. Anaheim, Dept. AM-10 Long Beach, CA 90804	Free	no later than Aug. 1 for Christmas delivery	—	—	$250 to $520	$440 to $690
Criterion Manufacturing Co. 620 Oakwood Ave., Dept. AM-10 West Hartford, CT 06110	Free	3-4 months; no later than Aug. 1 for Christmas delivery	—	—	$230	$400 to $625
Edmund Scientific Co. 300 Edscorp Bldg., Dept. AM-10 101 E. Gloucester Pike, Barrington, NJ 08007	Free	week to to 10 days, no Christmas orders after Thanksgiving	$150 to $190	—	$250 to $499	$590 to $660
A. Jaegers 691A Merrick Rd., Dept. AM-10, Lynbrook, NY 11563	Free	normal mail when telescope is in stock	—	$138 (not equatorial)	—	—
Star-Liner Co. 1106 S. Columbus Blvd., Dept. AM-10 Tucson, AZ 85711	50¢	45-60 days, no later than Aug. 1 for Christmas delivery	—	—	$292 to $1,045	$405 to $1,175
S & S Optika 3853 S. Broadway, Dept. AM-10 Englewood, CO 80110	$1 - refundable upon purchase	3 months	—	$160 to $265	$340 to $700	$515 to $900

* The above delivery dates were stated verbally by manufacturers and may not reflect realistic Christmas rush delivery schedules. To avoid disappointment, reflector buyers should place orders with full anticipation that their telescope may not arrive until after the first of the year.



Larger refractors are good values if you have specific need for a refractor, but they are extremely expensive and require permanent housing.

A popular beginner's telescope is the widely available 2.4 inch (60mm) refractor. It is in this small aperture category that the refractor is a fine value. Small refractors are readily available and often provide viewing satisfaction belying their modest prices. Standard sizes are the 2.4 inch (60mm), 3 inch (76.2mm), 3.1 inch (80mm) and

Serious exploration of the night sky requires large aperture, and the Newtonian reflector telescope provides it economically. The Criterion RV-6 Dynascope — a six inch aperture Newtonian — typifies this economy. For $244.95 (which includes a $15 crating charge), you can find features that are not available on the least expensive three inch refractor. The RV-6 is not only equatorially mounted; it also includes an electric clock drive and setting circles. Two achromatic Ramsden eyepieces (9mm and 18mm respectively) provide magnifications of 68 and 136 power with the 48 inch focal length, f/8 parabolized mirror.

4 inch (102mm). The price obeys the laws of diminishing returns. A four inch instrument, for example, has 65 percent greater resolving power than a 2.4 inch, but its price may be 15 times as great.

Virtually all major department stores and some camera shops sell refractors of 2.4 and three inch apertures. Refractors with four inch apertures are available almost exclusively through the mails. Some price shopping is definitely in order. While there are many American wholesaler/importers distributing telescopes to department store chains, there are relatively few Japanese manufacturers. (Interestingly, one major Japanese manufacturer distributes to the majority of American importers.) Identical telescopes are sold under many different brand names, often at vastly different prices. Even though only a few oriental companies actually manufacture small refractors, they offer many different models with a wide range of optical quality.

Imported refractors are invariably equipped with a host of accessory items — typically two or three eyepieces for low, medium and high magnifications; a Barlow lens which doubles or triples the magnification of each eyepiece; a star diagonal for ease in viewing objects directly overhead; an erecting prism (an astronomical telescope normally produces an inverted image) for terrestrial viewing; a sun screen for projecting and (safely) viewing the sun; a moon filter, and often a dense filter for viewing the sun directly. *Discard the solar filter as soon as you purchase your telescope*: Sun filters which screw into the eyepiece are generally not safe. Over-the-aperture sun filters stop harmful radiation from entering the telescope and are the only totally safe devices for direct solar viewing.

In general, spotting scopes and other 60mm refractors costing less than $75 are intended exclusively for terrestrial viewing, and their optical quality is inferior to an astronomical telescope. Furthermore, they lack accessory features such as a star diagonal and interchangeable eyepieces, making them less functional than a telescope specifically designed for astronomical viewing.

Another factor besides optical quality influencing price is the telescope mounting. The least expensive mounting is the altazimuth type — often a simple fork design that requires two separate motions in altitude and azimuth to follow an object across the sky. As a consequence, much of your observing time is spent continually recentering your subject. In more expensive models, the altazimuth mount is equipped with slow motion controls which minimizes centering problems.

Be prepared to spend between $75 and $100 for a 2.4 inch refractor of "adequate" quality for sky viewing with an altazimuth mount and few accessories. The upper limit for a 2.4 inch refractor on an altazimuth mount is about $300. Generally, as the price increases with various models, so does the overall mechanical quality improve—tripods become more sturdy, and the accessory gadgets may outweigh the telescope itself.

Much more convenient is the 60mm refractor with equatorial mounting which requires only a single motion (in right ascension) to keep the observed object centered. Convenience must be weighed against cost, because an equatorial mounting may double the price of a refractor. For ultimate convenience, clock drive systems are available with equatorially mounted refractors. With an electric clock drive, you're free to concentrate on viewing while your object remains centered for hours at a time.

Costs for equatorially mounted 60mm refractors vary between $175 and $600.

Whether your choice of mount is altazimuth or equatorial, mechanical rigidity will be an important factor to your viewing pleasure. No matter how fine the telescope may be optically, it is useless if it trembles in a slight breeze. If you are able to inspect your instrument before purchase, rap the tube sharply while observing an object at high magnification. If the instrument requires more than five or six seconds to settle, it may prove more frustrating than rewarding.

While today's high quality 60mm refractor sheds *some* doubt on the wisdom of investing in a three inch refractor, a three inch aperture provides better resolving power (ability to separate two points of light) and light grasp (ability to see dim stars) than a 2.4 inch. Prices range from $200 to $1,020.

The next largest size telescope that will allow observation of more useful detail in celestial objects than could be viewed in a 3 inch is the four inch aperture refractor. This size telescope allows the observer to "graduate" to additional celestial objects.

From stripped down, bare bones equatorial minimum to pedestal mounted, gadget-fat maximum, four inch refractors cost between $420 and $2,500. Priced beyond the realm of most pocketbooks, refractors larger than four inches require both permanent housing and a confirmed refractor fan.

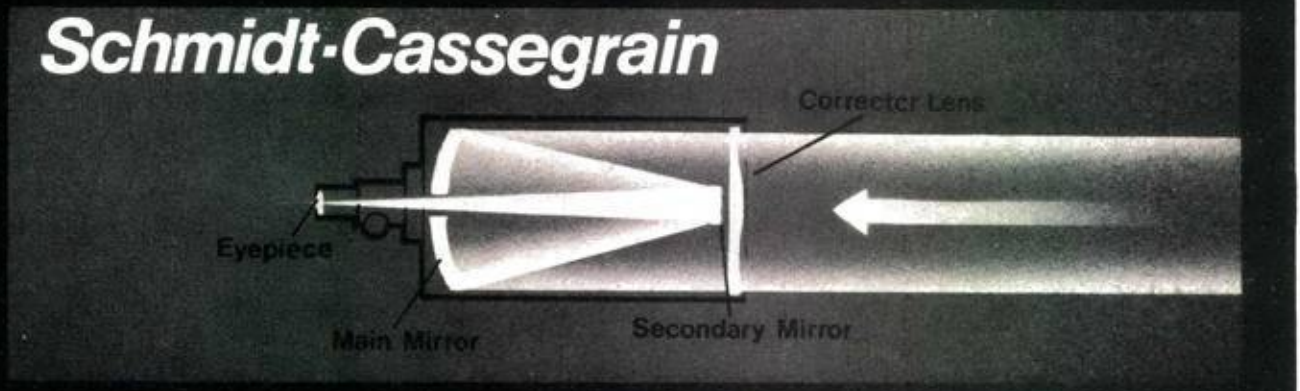
A modest sum spent on a small refractor is good for many years of enjoyable viewing. Though many astronomy enthusiasts will aspire to higher apertures, others will find the small instruments totally satisfactory. Many of the great observational astronomers of the past — such as Dawes, Webb and Olcott — did most of their work with three and four inch refractors.

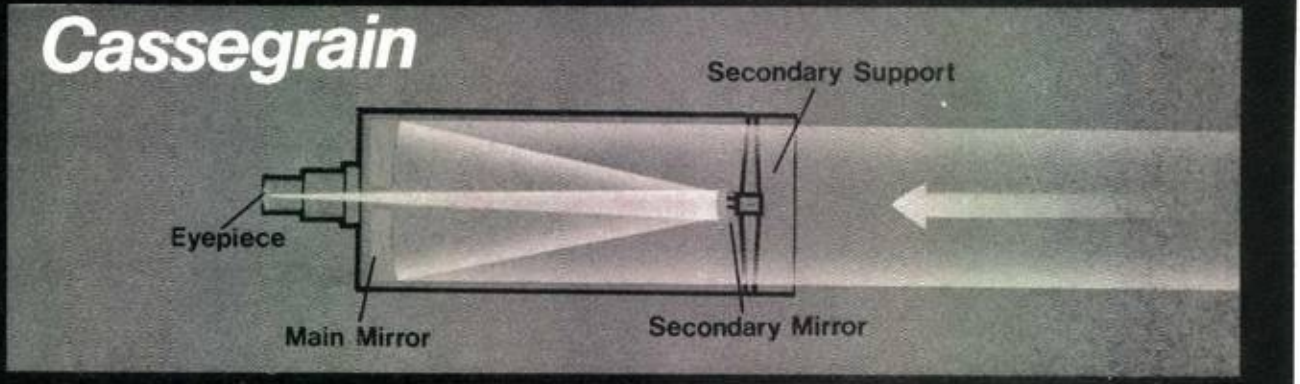
Reflectors

If any telescope can be considered the astronomy enthusiast's telescope, it must be the Newtonian reflector. This telescope has a concave primary objective mirror which focuses and reflects light to a smaller, flat secondary mirror called a diagonal. The diagonal, tilted at a 45 degree angle to the optical axis of the primary mirror, reflects the image produced by the primary to an eyepiece which magnifies it (see diagram, page 62).

CATADIOPTRIC TELESCOPE MANUFACTURERS

Name	Where Available	3"	3.5"	5"	6"	7"	8"
Celestron Pacific 2835 Columbia St. Box 3578-AM Torrance, CA 90503	mail order and selected dealers	—	—	$720	—	—	$845
Criterion Mfg. Co. 620 Oakwood Ave. Dept. AMB-10 West Hartford, CT 06110	mail order only	—	—	—	—	—	$875
A. Jaegers Dept AM-75 691 Merrick Rd. Lynbrook, NY 11563	mail order only	$200 (no tripod)	—	—	—	—	—
Questar Corp. Consumer Dept. 75-A New Hope, PA 18938	mail order only	—	$1,140-$1,740	—	—	$2,440-$3,895	—
Starliner Co. 1106 S. Columbus Blvd. Dept. AM-10 Tucson, AZ 85711	mail order only	—	—	—	$725	—	$895-$1,448





The biggest advantage of the Newtonian reflector is its low cost. The least expensive four inch equatorial refractor without clock drive costs $420, whereas the most expensive four inch equatorial Newtonian reflector with clock drive costs $265.

Light passing through a lens always creates color distortion called *chromatic aberration.* In the refractors discussed in this article, this distortion is minimized by specially designed two-element objective lenses (*achromatic lenses*) which correct most of the visible color distortion. Since light does not pass through any lenses in the Newtonian reflector, chromatic aberration is eliminated. On the other hand, a refractor generally has a slight advantage in performance over a Newtonian reflector of the same aperture up to seven inches. Secondary mirror obstruction in a Newtonian results in marginal loss of contrast, brightness and image definition.

The Newtonian's open tube allows dust and film to accumulate on optical surfaces, so it must occasionally be dismantled for cleaning. The aluminum coating of the exposed mirror surfaces can deteriorate over the years — especially in zones of severe air pollution — so periodic recoating may be necessary. Furthermore, because the reflector uses two reflective optical elements to bring light rays to a focus in front of the eyepiece, it is essential that they both be centered or collimated — a frequent and unavoidable operation if the telescope is transported or jarred. These operations are not difficult, however, and the reward — for a given instrument — is the greater performance only large apertures will yield. (Watch for "Collimating Your Newtonian" in December's Equipment Atlas.)

Quality reflectors are not available as shelf items in department stores and must be ordered, without exception, by mail. Unlike refractors, Newtonian reflectors are manufactured by American companies. Since there are fewer than 10 such companies in the United States, competition is very keen. As a result, you, the buyer, benefit by receiving the highest optical quality each manufacturer can provide. Reflectors are generally made as orders come in, so a buyer should be prepared to wait from one to eight months for delivery of his telescope. If you order a Newtonian reflector this month, you definitely should not expect delivery before Christmas.

Price variations within a Newtonian reflector size are due less to variations in optical quality and more to differences in accessory equipment and mechanical engineering. For example, almost without exception, Newtonian reflectors in all sizes are mounted equatorially — but the sturdier the mount, the higher the cost.

Mirror specifications in manufacturer's catalogs and literature provide clues to optical quality. The following are three guidelines to watch for:

1) Both the primary and secondary mirrors should be figured to at least 1/4 wave. You will pay increasingly more for mirrors figured to 1/8 or better. Mirrors of less than 1/4 wave will not produce adequately sharp images for celestial viewing. Both mirrors must match in terms of wave, or one will cancel the effect of the other.

2) The primary or objective mirror should be parabolized with a focal ratio of f/6 — f/8. Newtonians with focal ratios of f/4 or f/5 are considered rich field telescopes and have limited general viewing applications (see Equipment Atlas, June 1975).

3) If the primary mirror is not parabolized, it should have a focal ratio no lower than f/10. These are usually the least expensive Newtonians available.

When you start searching for a Newtonian reflector, you will not find the department store refractor superpower gimmickry.

Refer to the Newtonian reflector telescope manufacturers table accompanying this article for the price ranges you can expect with four, six and eight inch models.

The worldwide popularity of the Newtonian reflector speaks highly of its economy and usefulness. The buyer must weigh for himself the advantages and disadvantages of reflectors and refractors.

Catadioptrics

A modern blend of refractor and reflector, the catadioptric or compound telescope system comes in two basic designs for visual observing — the Maksutov and the Schmidt-Cassegrain. Light rays entering the telescope are "folded" and amplified by a lens/mirror partnership resulting in a very compact instrument. A typical eight inch model weighs less than 24 pounds with a tube only 1-1/2 feet long.

The catadioptric telescope has a completely closed tube, protecting mirror coatings from the elements and eliminating thermal currents.

Each telescope type offers its own special appeal and features for consideration. Refractors are noted generally for sharp planetary images; reflectors supply the best views in color contrast — double stars and nebulae, for instance, and catadioptrics are portable and produce the sharpest images over the widest field.

Remember to avoid any scope that is too large for your familiarity with equipment. And above all, especially with a small refractor that comes in a "nice" wooden storage box, don't disassemble your telescope because the temptation is too great to avoid the fuss of setting it up each time you want to use it. It is only actual use of the telescope that eventually produces a good observer and a happy and satisfied astronomy enthusiast.

Thomas R. Cave is currently president of Cave Optical Company and has 40 years experience in selecting and using all types of telescopes. James Mullaney has viewed thousands of deep sky and planetary objects over the past two decades with a variety of telescopes up to 30 inches aperture.

STAR DOME

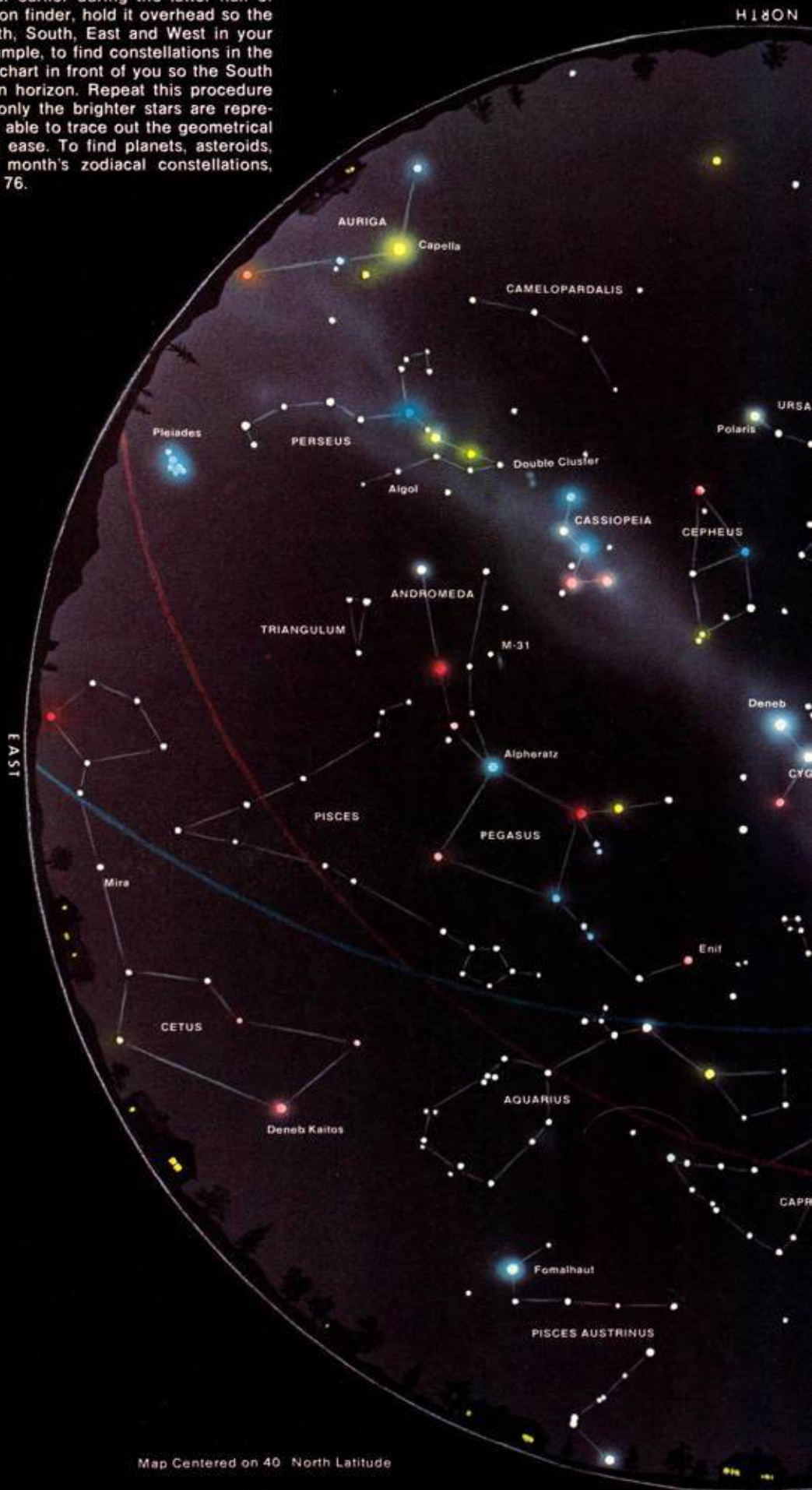
OCTOBER

Two seasonal star patterns — a triangle and a square — share our October Star Dome. The summer triangle, outlined by the brilliant gems Vega, Deneb, and Altair, dominates the western sky. The three constellation figures connected with the triangle — Lyra the harp, Cygnus the swan, and Aquila the eagle — seem to slowly retreat toward the western horizon, making way for the oncoming autumn constellations.

The great square of Pegasus is the second dominant star pattern in this month's sky. The winged horse seems to be leading the autumn figures into view. It now appears almost directly overhead as a rectangle of second and third magnitude stars. The trunk of the horse's body fills the great square as he flies upside-down across the autumn sky. From the star Scheat in the square's upper right corner, two front legs kick out along two rows of third and fourth magnitude stars. Pegasus' neck and head follow a row of fourth magnitude stars extending down from the square's lower right anchor, Markab. Second magnitude Enif marks the tip of Pegasus' nose.

Roughly halfway between Pegasus and the Big Dipper (now low on the northern horizon) lies another easily found constellation, Cassiopeia the queen.

This Star Dome rendering approximates the sky as it appears at about 11 p.m. Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.



Map Centered on 40° North Latitude

Her W-shaped pattern of five second and third magnitude stars is unmistakable.

Cassiopeia is the site of a famous star explosion or *nova* which occurred in 1572. Over a short time, a star within the constellation grew bright enough to be seen during the day, and rivaled Venus' brilliancy. The nova is now referred to as "Tycho's star" because astronomer Tycho Brahe kept detailed records of the event. Today, only two faint telescopic stars exist near the place where the nova exploded.

The "W" star pattern is commonly pictured as a chair or throne holding Cassiopeia. In mythology she is the wife of Cepheus, king of Ethiopia; his constellation figure stands near Cassiopeia.

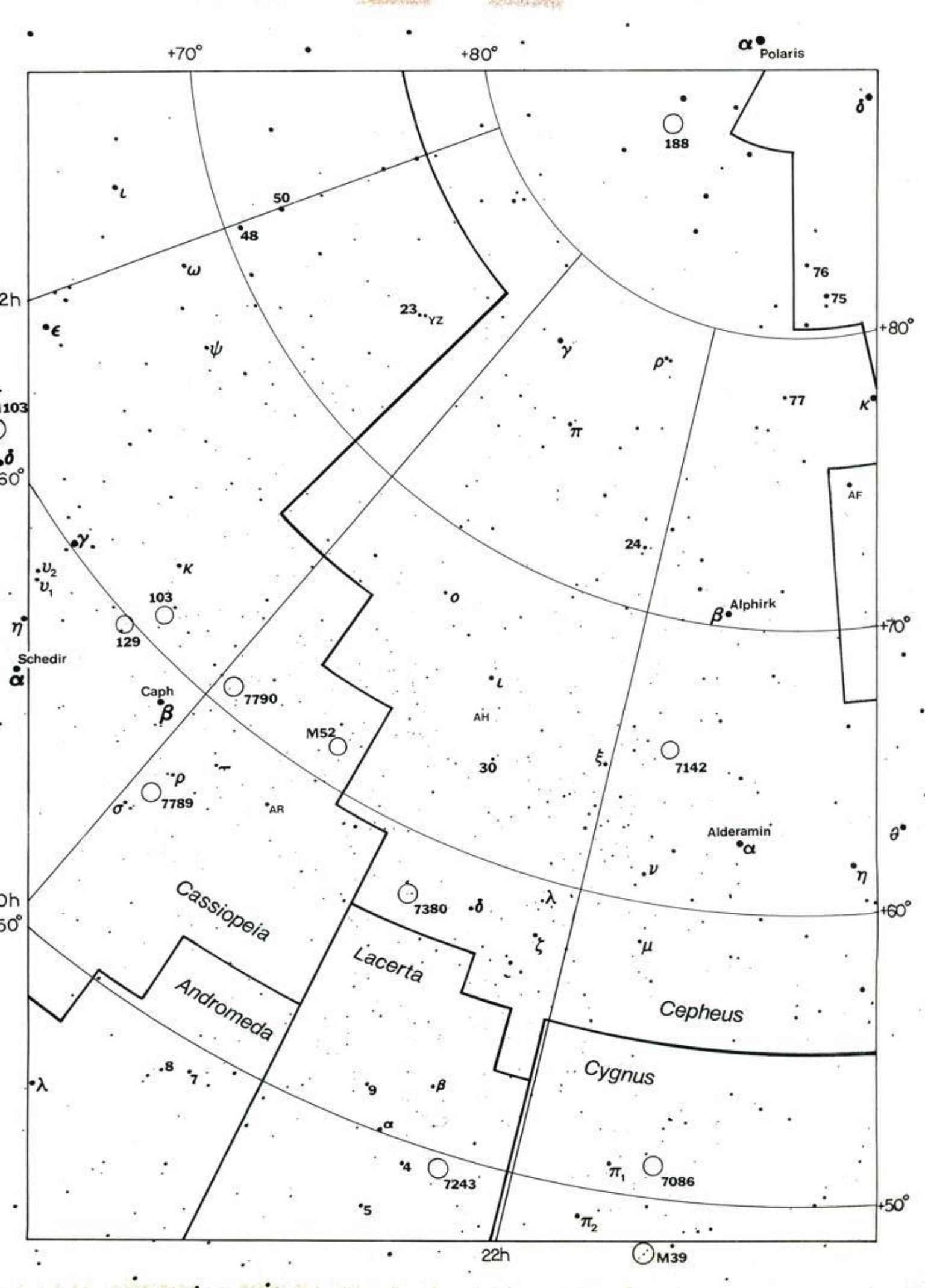
Circumpolar constellations such as Cepheus (and Cassiopeia) are visible for most of the year. Only when this ancient monarch stands on the southern horizon in early spring is it difficult to observe. Then the horizon haze may dim this faint group of stars for observers in some areas. Though fairly inconspicuous, Cepheus is easily traced out in the nighttime sky — shaped roughly like a square with the top forming the base of an isosceles triangle. The topmost star of the constellation [Gamma (γ)] marks the king's head; it is the nearest bright star west of Polaris.

Cepheus lies partially in the Milky Way, but unfortunately is not graced with the abundance of galactic objects found in other Milky Way constellations. It does, however, contain a multitude of double and variable stars to keep viewers busy for the evening.

Though Cepheus may not be rich in deep sky objects, much celestial lore is devoted to the constellation — dating back to the Chaldeans of 2,300 B.C. But the Greek stories from around 500 B.C. are the most fascinating and colorful.

The Greeks depicted the star group as the king of Ethiopia, and honored him with a place among the stars because he was a member of the famous band known as the Argonauts (who sailed with Jason to capture the Golden Fleece). Besides Cassiopeia, Cepheus' beautiful daughter Andromeda lies near him in the sky. The ancient Greeks relate a story concerning the family, and include Andromeda's husband Perseus (another circumpolar constellation).

Cassiopeia was a vain woman, and her vanity often caused problems for both herself and her husband. Her persistent boasting that her daughter Andromeda was more lovely than the sea nymphs (the pride and joy of Neptune, god of the sea), brought the wrath of gods upon her. Neptune became irritated with Cassiopeia and subjected Ethiopia to famine, tidal waves and general destruction. He declared the chaos would cease only when Andromeda was sacrificed to a sea monster along Ethiopia's coast. Reluctantly, Cepheus ordered his beautiful daughter chained to a boulder on the seashore to await her fate.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Nearby, Perseus was journeying to his native country fresh from battling the fearful Medusa (a horrible creature with snakes for hair and a gaze which turned men to stone). He was flying above Ethiopia with the winged sandals Mercury had loaned him to help him slay the Medusa. As he spied Andromeda awaiting her death along the coast, he immediately flew down to rescue her. With amazing skill, Perseus killed the sea monster and rescued Andromeda. The powerful King Cepheus was so pleased he granted the young man his daughter's hand in marriage.

Close-Up on the Cepheus Region

None of the stars in Cepheus are particularly bright. Alpha (α) Alderamin is the most brilliant star in the constellation. Of spectral class A5, it appears white and has a magnitude of +2.5. It also marks the lower right hand corner of the square depicting Cepheus in the sky.

Alderamin will one day be the pole star — as Polaris is today — because of the phenomenon known as *precession*, or the slow change in the direction in space of Earth's axis. Precession can be compared to a top's wobble as it begins to slow down. On Earth, the effect is caused by the gravitational pull of the sun and moon on Earth's equator. Earth is not a perfect sphere; it bulges slightly at the equator, and its axis is tilted at 23-1/2 degrees to the ecliptic plane (or annual path of the sun as seen from Earth). The sun's and moon's gravitational attractions fight to pull Earth in different directions. The sun tends to pull the equatorial bulge toward the plane of the ecliptic, and the moon's gravitational force pulls the bulge toward the plane of the moon's orbit. So Earth seems to wobble as it is pulled in both directions, and the pole sweeps out a giant circle in the circumpolar constellations (completed in about 26,000 years at the present rate). In about 5,600 years, our descendants will use Alderamin as a northern reference point. Another future pole star is Vega in Lyra.

Forming an isosceles triangle with Gamma (γ) and Pi (π) Cephei is NGC-40, a faint planetary nebula of magnitude 10.2. Though hardly a spectacular object, on a fine clear night the relatively barren surrounding star field would make the searching fairly easy and rewarding.

Located within four degrees of the north pole is the faint (magnitude 9.3) and extremely old open cluster, NGC-188. Spread over a field of 15 minutes of arc, the cluster is a challenge for observing.

The Milky Way cuts through only a small section of Cepheus near the stars Delta (δ), Epsilon (ϵ), Eta (η) and Lambda (λ), and in this region is one of several dark nebulae — a common characteristic of the galaxy. Because of their darkness, these features are known as the "Coal Sacks". One in the southern hemisphere near the Southern Cross is a more striking feature than that found in Cepheus. These dark lanes of obscuring dust and gas obliterate the background stars and appear as vacancies in space, absorbing and diverting light before it reaches the eyes of observers on Earth.

Cepheus contains a wealth of double stars — many with easy separations and well-balanced magnitudes making them enjoyable to seek out with the telescope. Many of the pairs are white, blue or yellow combinations.

Eyepiece Impressions

Many observers have remarked that the constellation Cepheus is much more barren to the eye than to the telescope. With the exception of the cluster M-52, all of this month's subjects are bright variable and double stars easily spotted with the unaided eye, but whose hidden beauty is only revealed in a telescope. A rich portion of the Milky Way passes through part of Cepheus, providing as Webb points out "splendid sweeps and curious groups".

Beta (β) Cephei

The first of many fine double stars in this area, Beta occupies the top right corner of the house shaped figure of Cepheus (when viewed with the peak of the roof marked by the star Gamma). This unequal pair consists of third and eighth magnitude suns separated by 14 seconds of arc. Both components appear blue-white, although other colors have been reported including greenish-white and purple.

Beta's real charm, however, lies not in its color but rather its magnitude contrast. A three inch refractor at 45 power shows the little star neatly tucked in beside its 100-times brighter primary. Larger instruments seem to further enhance this striking contrast, and in an 8 or 10 inch reflector this object ranks as one of the finest doubles in the north polar region of the sky. Pairs like Beta with small attendants are best seen on those rare nights of good seeing (image steadiness) and transparency (atmospheric clarity).

The primary star itself is a very close and rapid spectroscopic binary. Spectral analysis with large observatory telescopes reveals that the two suns waltz about each other with a period of less than five hours! The combined triple star system is located more than 500 light-years from our sun.

Xi (ξ) Cephei

Shining right in the middle of the house [whose four corners are marked by the stars Alpha (α), Beta, Zeta (ζ) and Iota (ι)] is another fine double. This is Xi Cephei, a duo of 4.6 and 6.6 magni-

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	ο	Omicron	φ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ε	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

Star Magnitudes

—1 0 1 1½ 2 2½ 3 3½ 4 5

○ Cluster or Nebula

⊙ Variable Star

\+ Nova

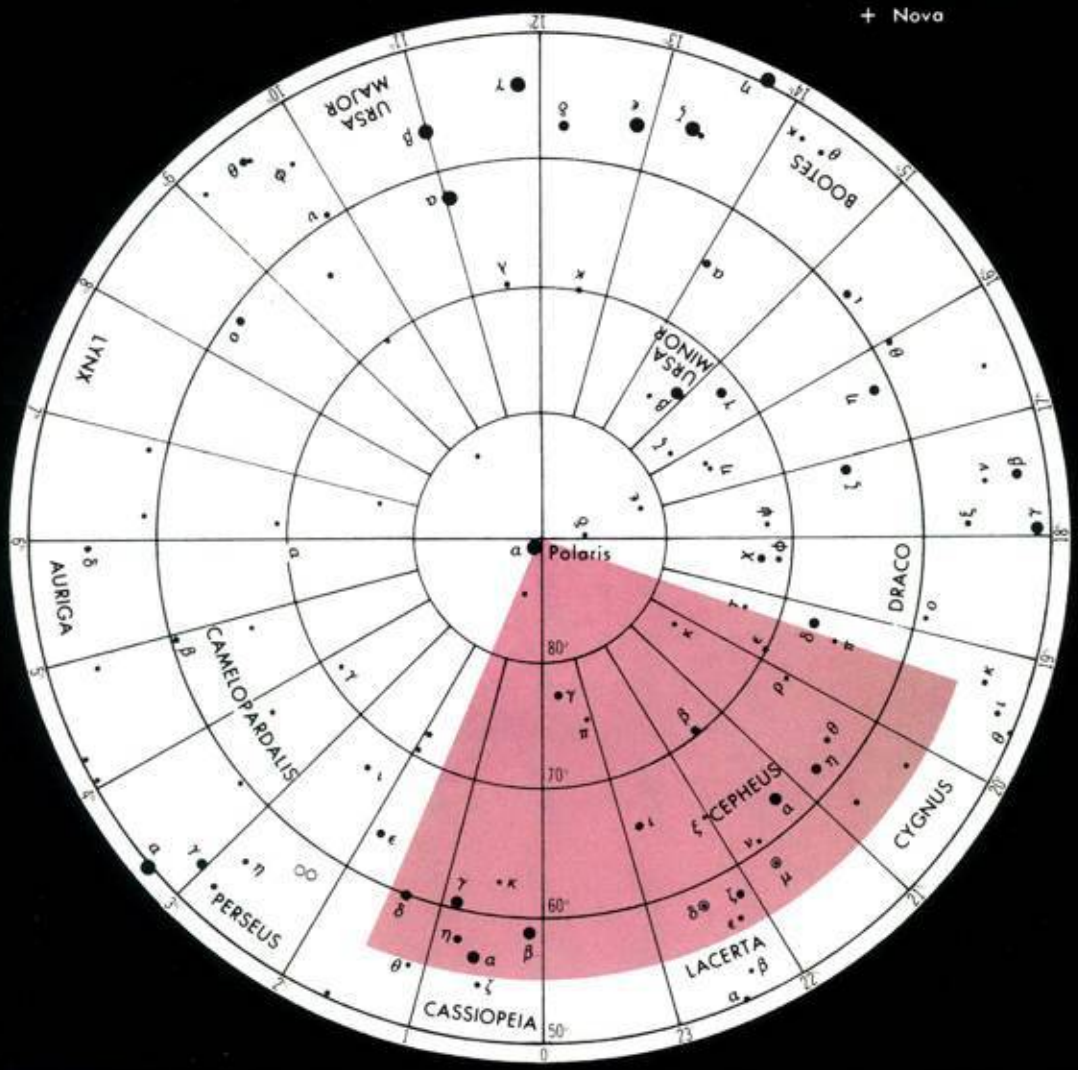


TABLE OF OBJECTS — CEPHEUS REGION

Object	Type	Magnitude	Size/Separation	Period	R.A. (1950)	Dec.
NGC-40	planetary nebula	10.2	60" x 38"		00^h10^m	+72°15'
NGC-188	open cluster (oldest known)	9.3	15'		00^h39^m	+85°03'
κ Cephei	double star	4.4, 8.2	7"		20^h11^m	+77°34'
* β Cephei	double star	3.3, 8.0	14"		21^h28^m	+70°20'
* μ Cephei	red star	3.6—5.1		irregular	21^h42^m	+58°33'
* ξ Cephei	double star	4.6, 6.6	7"		22^h02^m	+64°23'
* δ Cephei	variable double star	3.8—4.6, 7.5	41"	5.4 days	22^h27^m	+58°10'
* ο Cephei	double star	5.0, 7.3	3"		23^h17^m	+67°50'
* M-52	open cluster	7.2	12'		23^h22^m	+61°20'

* Detailed description in Eyepiece Impressions

Map from **Guideposts to the Stars**; reprinted permission of MacMillan Publishing Co., ©1972 by Leslie C. Peltier.

Mu Cephei, Sir William Herschel's "garnet star", forms a narrow triangle with Alpha and Zeta against the Milky Way background. Its brilliant red color is obvious even in finders and binoculars. This restless variable supergiant of spectral class M, prototype star of the semiregular variables, is an outstanding sight in a four inch reflector at 40 power. The field of view in this case is one degree of arc. Artwork by James Mullaney.

An unusual pulsating double star, Delta Cephei is the prototyp of a famous and important family of variables known as th Cepheids (which are reliable distance determiners to remot clusters and galaxies). The star's two components resembl famous Albireo in Cygnus. A three inch Unitron refractor a 45 power offers a fine view of this pair in a field of view o one degree of arc. Artwork by James Mullaney.

tude stars only seven seconds apart. The brightness difference here is only two magnitudes as compared to nearly five for Beta, so Xi's chief attraction is its fine color contrast.

Various sets of hues have been given for this pair. Webb saw them as yellow and blue on some nights and as white and tawny or ruddy on others. Olcott states that both stars are bluish. A modern four inch reflector equipped with well-corrected eyepieces shows the primary as yellow and the companion blue or perhaps lilac. Medium magnifications are best for separating this rather tight pair.

Mu (μ) Cephei

Well-known as Sir William Herschel's "Garnet Sidus" or garnet star, Mu Cephei's striking color is obvious even in finders and binoculars. This unusual naked eye object forms a narrow triangle with Alpha and Zeta, standing out nicely against the Milky Way background when at maximum light.

Like most orange and red stars, Mu is variable in brightness — waxing and waning between magnitudes 3.6 and 5.1. No definite period has been found for this restless supergiant of spectral type M, and it is classified as semiregular. Mu is, in fact, the prototype star of this species of variable.

This star's hue depends on the size and type of telescope used to view it. It is definitely red in a finder, and a three inch refractor at 45 power shows it as a ruddy orange. Mu looks orange in an eight inch reflector at 60 power and mostly yellow in a 13 inch refractor at 145 power! Increased light grasp seems to spoil the effect in this particular case.

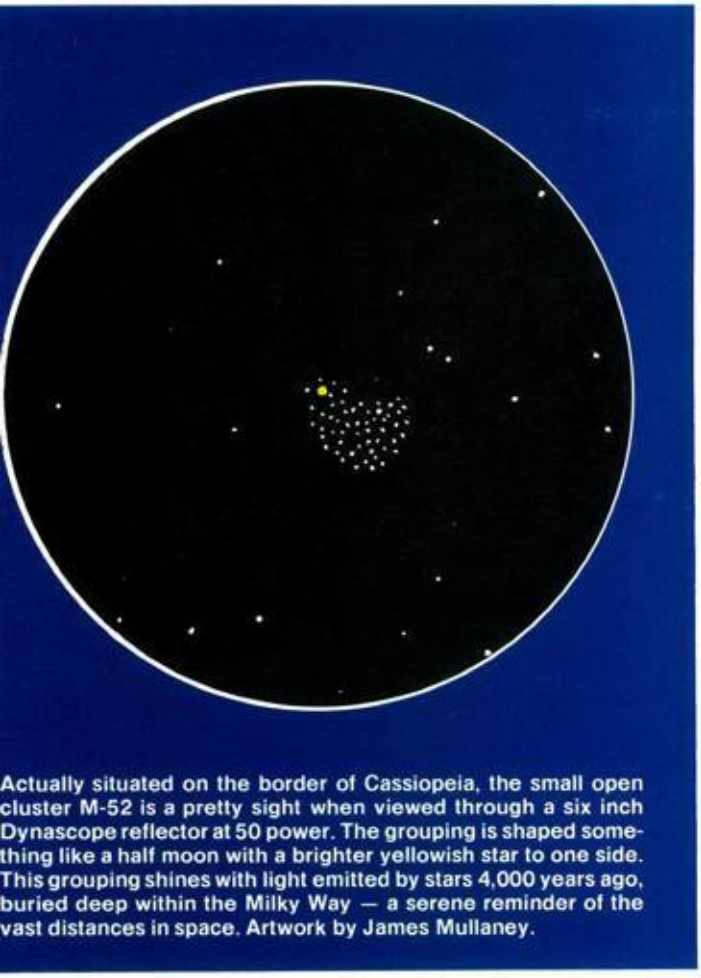
Another interesting aspect of viewing Mu is that the longer you stare at it, the brighter and less red it becomes. This is due in part to the eye's non-instantaneous adaptation to red light. Thus, quick glances are preferred to steady scrutiny for maximum effect in observing the colors of red stars. In all cases, a star will never look as strongly tinted as it does when first brought into the field of view.

Viewed through the porthole of a telescope's wide-angle eyepiece on a dark clear night, Mu glitters like some colossal interstellar traffic beacon amid the hosts of suns brimming the edge of our galaxy.

Delta (δ) Cephei

The bottom left corner of Cepheus is actually marked by a group of three stars — one of which is Delta, an unusual pulsating double. This object's fluctuation from 3.8 to 4.6 magnitude over a period of 5.4 days can easily be followed with the unaided eye by making frequent comparisons with surrounding stars of constant light such as Zeta and Epsilon (magnitudes 3.6 and 4.2, respectively).

Delta is the prototype of a famous and impor-



Actually situated on the border of Cassiopeia, the small open cluster M-52 is a pretty sight when viewed through a six inch Dynascope reflector at 50 power. The grouping is shaped something like a half moon with a brighter yellowish star to one side. This grouping shines with light emitted by stars 4,000 years ago, buried deep within the Milky Way — a serene reminder of the vast distances in space. Artwork by James Mullaney.

tant family of variable stars known as the Cepheids. Found in many remote clusters and galaxies, these objects serve as reliable distance indicators due to a distinct relationship between their periods of pulsation and their intrinsic or real luminosities. Much of our knowledge of the distance scale of the universe has been derived from stars like Delta, which is itself relatively nearby at "only" 650 light-years.

In addition to being an important variable, Delta is also a very attractive double star for small telescope users (resembling famous Albireo in Cygnus). The pale orange primary has a 7.5 magnitude blue companion at a distance of 41 seconds of arc, providing a fine "field glass double" as Olcott refers to it. The pair is striking in a 2.4 inch refractor at just 30 power; much more magnification on any scope spoils the effect by separating the components unduly.

Webb describes Delta as very yellow and blue, adding "especially fine pair, somewhat like Beta Cygni". A fainter, nearly equal white pair of stars lies close to Delta, adding to the beauty of the scene. Barns, using his 10 inch homemade reflector in clear California skies, mentions "two lambent clusters in field". These apparently are simply concentrations in the rich Milky Way background rather than actual physical groupings.

Omicron (o) Cephei

Three degrees northeast of third magnitude Iota (ι) is another colorful celestial duo. This is Omicron Cephei, a close blend of 5.0 and 7.3 magnitude stars less than three seconds of arc apart. Unlike Delta, their yellow and bluish tints require medium to high magnifications for a proper view (about 150 power on a six inch reflector).

Barns brings out an interesting point in his entry on Omicron: "Their primrose and lilac tints seem to appear stronger with relatively poor seeing, or through a faint aurora, as is the case with circumpolar stars in particular. The sharpest skies are not always the best for comparative observation." Color studies on unsteady nights give the same result as a slight defocusing of the image. Both spread the light entering the eye over a greater area of the retina, making perception of delicate hues easier.

M-52

A line drawn from Beta through Iota Cephei, prolonged about 2/3 its length, points directly at the star 4 Cassiopeiae. Just a degree south of this fifth magnitude object is the small open cluster M-52. Although some older lists place this cluster in Cepheus, it is actually situated just over the border in Cassiopeia.

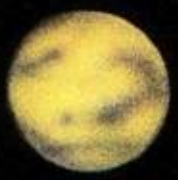
A three inch refractor or four inch reflector at 45 power shows a compact, rich uniform glow of stars shaped something like a half moon, with a brighter yellowish star to one side. This group somewhat resembles the well-known open cluster M-11 in Scutum, but is a full magnitude fainter and not as crowded with stars. M-52 has the integrated or combined brightness of a 7.2 magnitude star and is some 12 minutes of arc in extent. Catalogs indicate about 120 member stars in the cluster.

Webb describes this object as "irregular with orange star, as is frequently the case". As we have mentioned in the past, such an association of orange and red stars with open clusters would appear to be more than mere coincidence. However, professional astronomers offer little on this possible relationship — perhaps because modern observational astronomy is rarely done visually anymore. While the effect is striking to the eye in the telescope, it is hardly noticeable in time exposure photographs or computer printouts!

This glittering stellar commune is more than 4,000 light-years from us, buried deep in the Milky Way. M-52 has a serene, remote and gentle look about it, bringing to mind something the famous observer Leslie Peltier once wrote: "Were I to write out one prescription designed to help alleviate at least some of the self-made miseries of mankind, it would read like this: One gentle dose of starlight to be taken each clear night just before retiring."

Try searching for M-52 with your telescope the next dark, clear night — it may be just what the "doctor" ordered!

Planet Finder



Ⓐ Mercury

Oct.	1
R.A.	13h19m
Dec.	-12°12'
Mag.	+2.0

Ⓑ Mercury

Oct.	15
R.A.	12h35m
Dec.	-3°35'
Mag.	+1.5

Ⓜ Mars

Oct.	1	15
R.A.	5h38m	5h58m
Dec.	+23°00'	+23°32'
Mag.	-0.2	-0.4

Ⓒ Ce

Oct.	1	15
R.A.	4h56m	4h51
Dec.	+16°59'	+17°
Mag.	+7.9	+7.9

SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

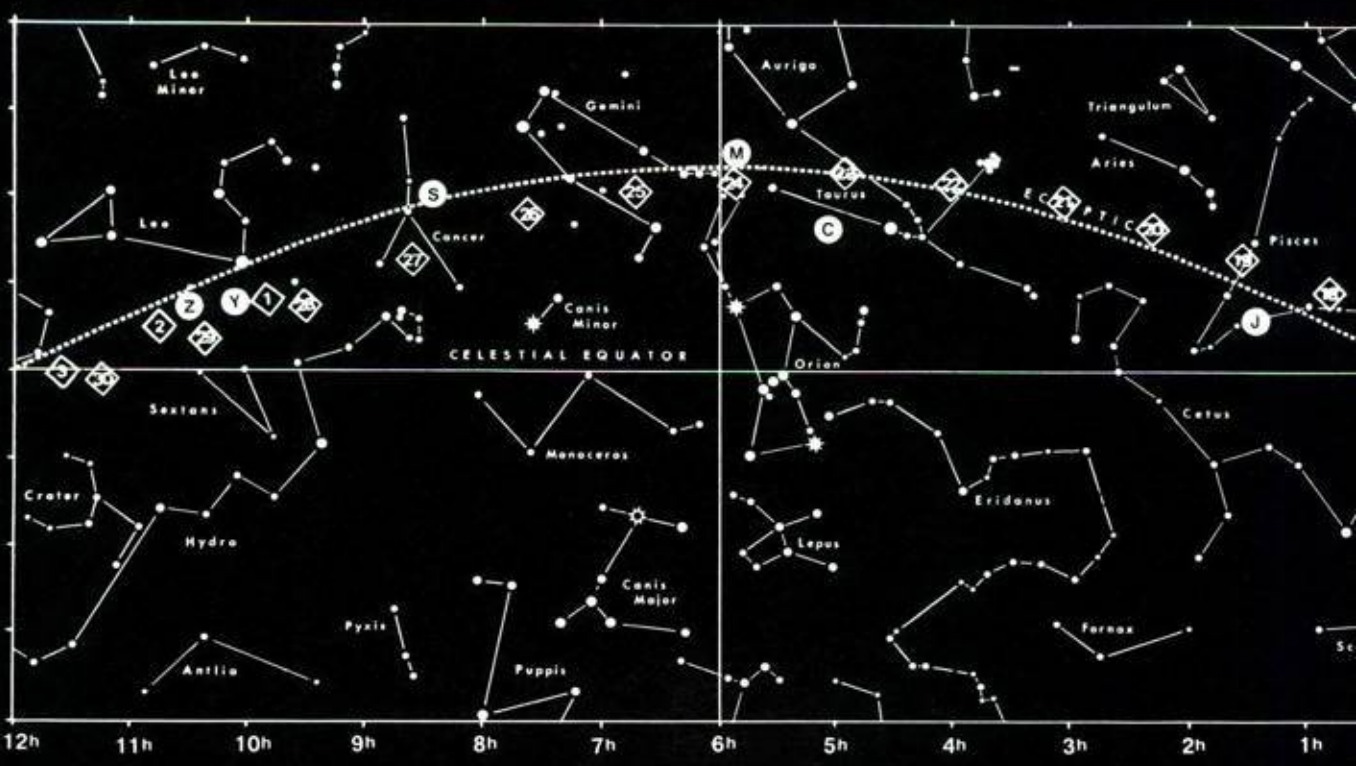
Oct.	1	15
R.A.	8h14m	8h17m
Dec.	+19°57'	+19°47'
Mag.	+0.5	+0.4

Ⓤ Uranus

Oct.	15
R.A.	14h00m
Dec.	-11°55'
Mag.	+5.5

Ⓝ Neptu

Oct.	15
R.A.	16h
Dec.	-20°
Mag.	+7.



The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec . = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag . = magnitude, a

October 1975

(V) Vesta

Oct.	1	15
R.A.	23h46m	23h36m
Dec.	-14°05'	-14°40'
Mag.	+7.1	+7.1

(J) Jupiter

Oct.	1	15
R.A.	1h20m	1h13m
Dec.	+6°46'	+6°04'
Mag.	-2.5	-2.5

(Y) Venus

Oct.	1
R.A.	9h58m
Dec.	+7°56'
Mag.	-4.3

(Z) Venus

Oct.	15
R.A.	10h34m
Dec.	+6°55'
Mag.	-4.2

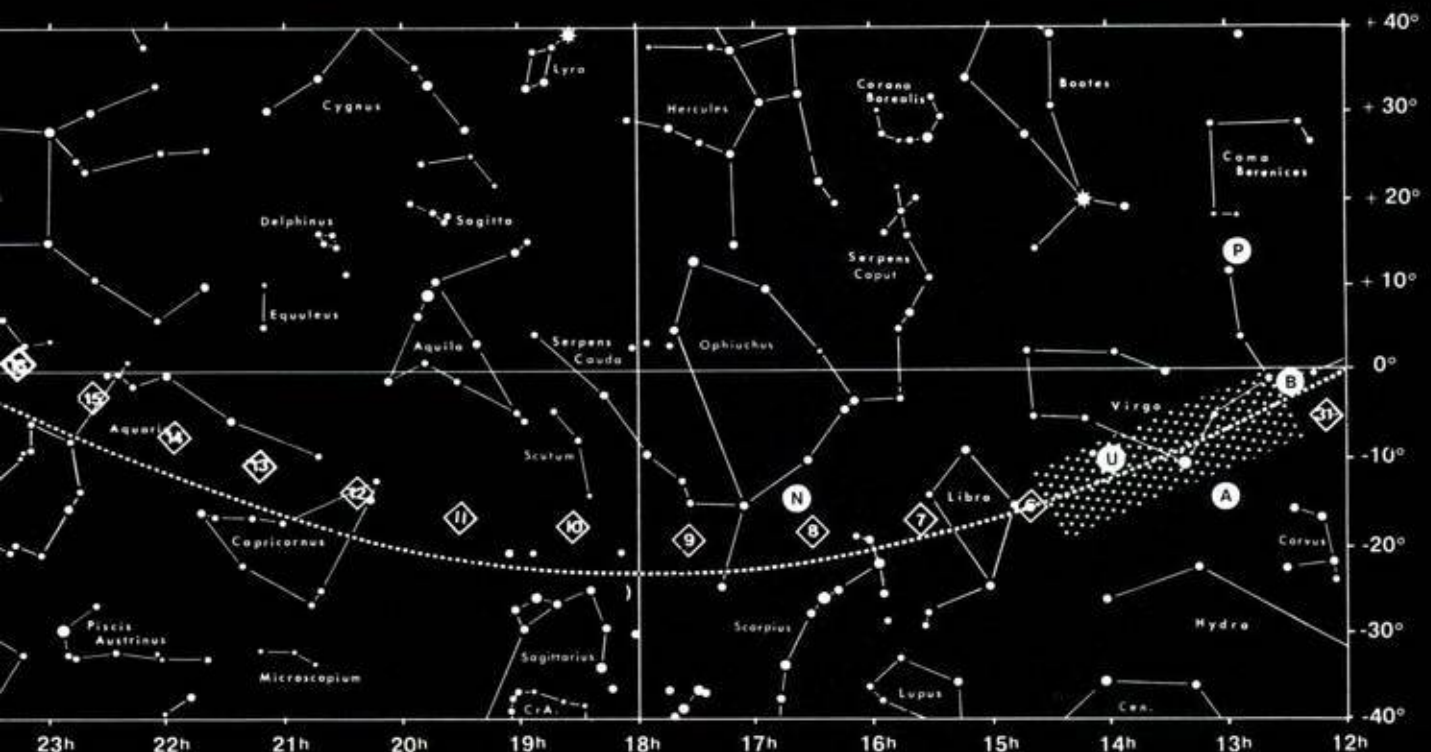
(P) Pluto

Oct.	15
R.A.	12h59m
Dec.	+11°21'
Mag.	+14

First Quarter
Oct. 11

Full Moon
Oct. 20

Last Quarter
Oct. 27



measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

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